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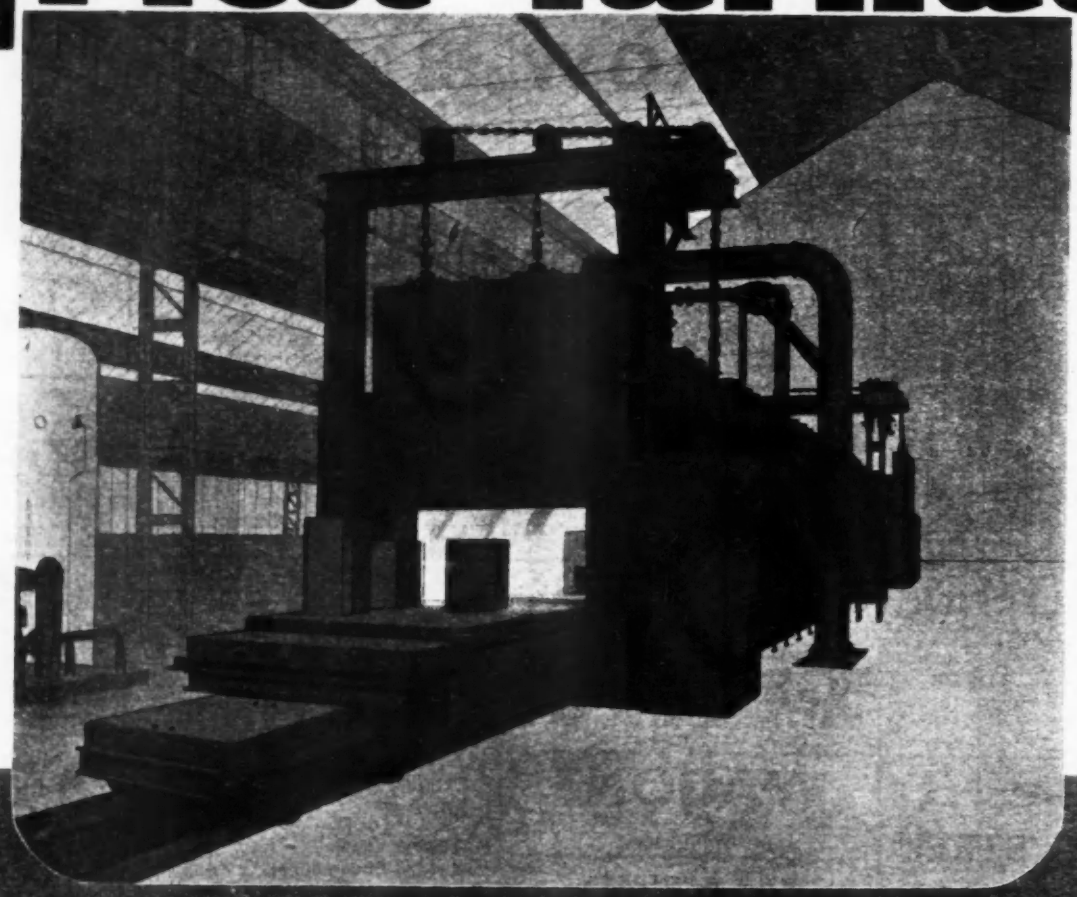

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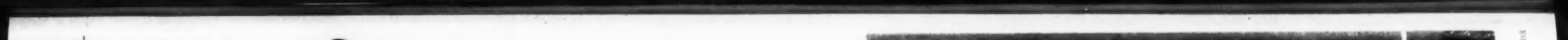
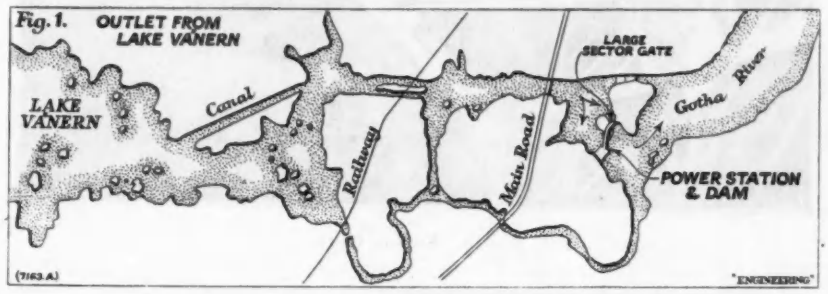


THE VARGÖN POWER STATION OF THE ROYAL SWEDISH BOARD OF WATERFALLS.

AMONG other duties, the Royal Swedish Board of Waterfalls supplies electrical energy over a large area of central and southern Sweden from three hydro-electric stations on the Göta River, which, from the point of view of flow, is the largest in the country. The first of these stations, that at Trollhättan, was brought into operation in 1910, and has at present an installed capacity of 140,000 kW, comprising 13 units utilising a head of 32 m. Lower down the river is the Lila Edet station, which was opened in 1926, and has an installed capacity of 26,000 kW, obtained from two Kaplan turbines operating under a head of 6·5 m. The third station, at Vargön, is situated between the outlet from Lake Vänern and Trollhättan, and was opened in 1937. It is also equipped with two Kaplan turbines with an aggregate capacity of 20,000 kW, which operate under the very low average head of 4·3 m. It is estimated that the total annual output from these three stations will be 1,355,000,000 kWh, though this figure has not yet been reached. This output is supplemented by auxiliary steam plant at Västeras and Gothenburg.



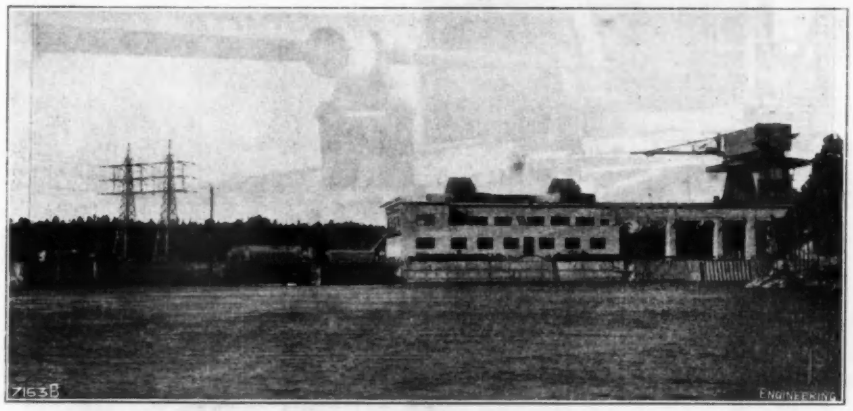


FIG. 2. VARGÖN POWER STATION AND DAM.

It is doubtful whether it would have been economical to develop the falls at Vargön had not the Board at the same time decided to regulate the flow of Lake Vänern. By fixing the height of regulation at 1·7 m., it has been possible to provide storage capacity equivalent to 850,000,000 kWh, or about 60 per cent. of the total quantity of energy which can be produced in a year of normal flow. There will thus be a surplus of reservoir capacity available for equalisation over several years, and, as a result, it will be possible to transmit so much energy to central Sweden that it will only be necessary to use the reserve steam plants to a very small extent. Under these conditions, the three stations on the Göta river will be run as base-load stations during the winter and as peak-load stations during the summer, and Lake Vänern will only be tapped when the flow at the other stations in the area is low. The dam at Vargön power station has therefore been designed for regulating purposes, while by placing the turbines above head-water level, intake gates have been dispensed with and the excavation to accommodate the draft tubes was reduced. The generators are placed on the roof of the building and are protected by removable steel housings, thus reducing the constructional costs.

The general layout of the works at Vargön will be clear from Fig. 1, while a view of the dam and power station appears in Fig. 2. As will be seen, the dam is built across the river and is provided with four openings, one of which is provided with a sluice gate and the other three with sector gates. The two sector gates nearest the power station are remote controlled from Trollhättan, a distance of some 15 km. The construction of the third sector gate, which is 13 m. wide and 12 m. high, is illustrated in Figs. 3 and 4, page 28. It is operated by means of cables which pass over two drums, each drum being driven through gearing by a 25-h.p. motor. These motors are installed in two houses, one on each side of the gate opening.

A section through the power house and one of the units is given in Fig. 5, Plate II, from which it will be seen that the flow of the water is such that a syphon is obtained. To generate the vacuum necessary in the space above the turbine at starting, an ejector is installed. The turbine gate apparatus is arranged so that the lower gate ring is on the same level as the highest head-water level. This obviated the necessity for installing intake gates. At the same time, the runner is accessible for inspection without the use of special shut-off equipment. The intake openings are each 18·93 m. wide by 9·7 m. high, and the turbine scroll has a maximum height of 16·35 m. The turbines, of which there are two, are of the Kaplan type, and, as shown in Fig. 5, Plate II, have vertical shafts. The output of each is 18,000 brake horse-power when running at 46·9 r.p.m., under a head of 4·3 m. The runners, one of which is illustrated in Fig. 7, Plate III, are 8 m. in diameter and are stated to be the largest in the world. The boss is of cast steel and weighs 54 tons, while the four blades are of stainless steel and each weighs 11 tons. They are adjusted to an angle corresponding to the gate opening, or, more correctly, to the head and flow, by means of a servo-motor in the boss, which is operated by the governor. A section through one of the turbines is given in Fig. 11, page 29. Generally speaking, this drawing applies to both sets, but the gates on No. 1 unit are vertical instead of being inclined, as shown. The crown plate and gate rings, which are illustrated in Fig. 8, Plate III, are of cast iron, while the ring forming the discharge chamber round the runner is of welded steel plate. The crown plate gate rings and discharge chamber are all made up of segments, which are bolted together. As will be clear from Fig. 11, one of the segments of the discharge chamber is designed so that it can be taken out, thus facilitating the removal of the runner blades.

The gates, which are 24 in number, are of cast steel. Their spindles project through stuffing boxes into the crown plate and are connected by levers and safety links to the operating ring. The links are designed so that, in the event of any obstruction occurring between two gates, the corresponding links will break and it will be possible for the other gates to close, thus preventing damage to the turbine or generator. The weight of the turbine is supported on 12 stays, which form a connection between the roof and the draft-tube concrete. The draft tubes are built of concrete, their design being illustrated in Fig. 5, Plate II. They are 17·85 m. deep below the runner and the cross-section at the outlet is 7·4 m. by 20·45 m. The upper portion of the draft tube immediately below the runner is lined with chrome-nickel steel plate, followed by mild-steel plate for a total distance of about 8·5 m. This lining is visible in Figs. 9 and 10, Plate III. In Fig. 9, the turbine intake can be seen in the background and in Fig. 10 the draft tube lining is surrounded by the wooden shuttering for taking the concrete. The main shaft is of forged Siemens' steel, and is 870 mm. in diameter. It is made in two parts, which are connected together by solid forged coupling flanges, in order to facilitate dismantling. The combination is bolted to the runner and the generator at the lower and upper ends, respectively, by solid forged flanges, and passes through the crown plate in a water-sealed stuffing box. The object of this box, however, is not so much to prevent the escape of water as the entrance of air, as, owing to the fact that the turbine is above high-water level, there is no pressure on the underside of the crown plate. The main bearing, which is bolted to the crown plate, as shown in Fig. 11, is fitted with a white-metal lined journal, and is force-lubricated by a pump, which is gear-driven from the main shaft.

Each unit is provided with a governor, which controls both the gate opening and the angle of the runner blades. These governors are of the automatic oil-pressure type, and consists of four parts: the governor proper, with its head and regulating valves; two servo-motors, one controlling the gates and the other the runner blades, and the oil pump and pressure receiver. In the case of No. 1 unit, the servo-motor controlling the gates is placed underneath the floor in the control room and is connected to the operating ring by levers, regulating shaft and rods. In the case of No. 2 unit, two servo-motors are used and are built into the wall, being connected directly to the gate-operating ring. Each governor head is driven by a synchronous motor. This is supplied from a synchronous generator, which is built in with the gearing and the shaft for the exciter and oil pump. The oil pump is gear-driven from the main shaft and has an output of 2,400 litres per minute. A separate electrically-driven pump is provided as a standby. The receiver is 2·4 m. in diameter and 4·65 m. high, so that like the governor and the pump, its dimensions are imposing. As the gates are open or shut by the action of the governor, oil is simultaneously admitted to the servo-motor controlling the runner blades so that the gate opening and the angular adjustment of the blades correspond. On test, a maximum efficiency of 93·5 per cent. was obtained when utilising 200 cub. m. of water per second under a head of 4·7 m. With a head of 2·7 m., the corresponding figure was 84·5 per cent. One turbine was constructed by Messrs. Karlstads Mekaniska Werkstads Aktiebolag, Karlstad, and the other by Messrs. Nydqvist and Holm A.B., Trollhättan, both runners being supplied by the former firm.

The turbines are direct-coupled to vertical-shaft alternators, each having an output of 12,000 kVA at 11 kV. As already stated, these machines, which like the other electrical equipment, were constructed by Messrs. Asea, Limited, Västeras, are mounted on a level with the roof of the building and are enclosed in removable steel-plate housings, an illustration of which is given in Fig. 12, on page 38. Owing to local demands for energy, one

alternator is designed to generate at 25 cycles and the other at 50 cycles. Owing to the low speed, viz., 46·9 r.p.m., at which they run, the external diameter of each stator is no less than 11·4 m., and it is 1·9 m. high. The frame is of welded construction, as shown in Fig. 13, on page 38, and the girders which support the segmental thrust bearing are made up of 50-mm. and 60-mm. plates welded together. The bearing itself is designed to carry a load of 800 tons and, as will be seen from Fig. 11, is placed below the rotors. The magnet rim is built up of 20-mm. plate segments, which are held together by bolts, and is reinforced by a flywheel, which is also of bolted construction. The hub is of cast steel and the spokes are of H-section, to which stiffening plates are attached by welding. It is also fitted with heavy steel-plate rings for securing the spokes. The rotor assembly, a view of which is given in Fig. 14, on page 38, is made in two parts, and the weight of the frame, excluding poles and windings, is 43 tons. The total weight of one of the generators is 410 tons. The horizontal exciters are separately mounted and are driven from the turbine shaft by 1 to 10 gearing, so that the speed is increased to 497 r.p.m.

The output of the 25-cycle generator is transmitted to Trollhättan over two 11-kV lines, which were originally built to give a supply to smelting and paper works at Vargön. This supply is controlled by a 15,000-kVA, 12·3-8·7/10·5-kV regulating transformer, with an on-load tap changer giving a voltage range of 12·3 kV. to 8·7 kV in twelve steps. This enables the voltage of the line to be controlled at the Vargön end independently of the conditions at Trollhättan. The energy from the 50-cycle generator is stepped up to 55 kV in a 12,000-kVA transformer and is transmitted to Trolhättan at that pressure. This transformer is fitted with motor-operated tap-changing gear, giving a range of from 59 kV to 45 kV in eight steps. As the Vargön station forms part of the Trollhättan system, the generators are almost completely controlled from Trollhättan, indicators being installed to facilitate the work of the staff engaged in the starting-up and shutting-down operations. All the oil circuit breakers are remote-operated from Trollhättan, with the exception of the generator-isolating breakers and other switches controlling the local circuits. A large number of meter readings are recorded continuously at Trollhättan as described below.

The main switchgear, to which the generators are connected by cables, is situated at one end of the station. As shown in Fig. 15, on page 38, it is of iron-clad construction and comprises 300,000-kVA oil circuit breakers of the truck type, and isolating switches, as well as current and potential transformers. The transformers in the alternator neutral leads are, however, mounted beside the generators in separate frames. There are twenty-two switch units in all, which are connected to the 'bus bars for the 50-cycle and 25-cycle systems, respectively. The feeders to the adjacent smelting works can be connected either to the 50-cycle or the 25-cycle system, a two-way selector switch being built into the appropriate circuit breaker for this purpose. To prevent these switches from being opened when carrying current, they are arranged so that they can only be operated when the truck is withdrawn.

The control room is situated between the two generating sets and extends across the width of the station, the indicator boards and control desks being at one end while the metering and relay boards are at the other. The indicator boards each consist of five vertical panels. That on the left carries the instruments for the two generators and the outgoing lines, while that on the right carries the equipment for the local plant and the dam, as well as the temperature and signal indicators. The temperature indicators enable the temperatures of the stator windings and of the generator bearings to be observed, as well as those of the main guide and thrust bearings, the gearing bearing and the exciter bearing. The temperature of the oil in the gearbox can also be observed as well as that of the lubricating oil at the cooler inlet and outlet, that of the transformer oil and that of the cooling-air at the inlet and outlet. Any failure in the oil or water circulation results in an appropriate alarm being given. The control desk is also divided into two sections, each of which consists of five panels. One section controls the generators and feeders and is equipped with the usual mimic diagram, which incorporates the control switches. Switches for controlling the speed regulators and governors and for adjusting the voltage regulators, are also provided. The main field and booster switches and field rheostat are mounted on the vertical front, as also are push buttons for operating the turbine air valves and for flooding the generators with carbon dioxide. The mimic diagram is continued on to the feeder panels, where switches for controlling the feeders and the transformer-ratio regulator are included in the circuits. On the other desk are switches controlling the two motor generators for charging the battery, as well as the cell-coupler and spillway

THE VARGÖN POWER STATION, SWEDEN.

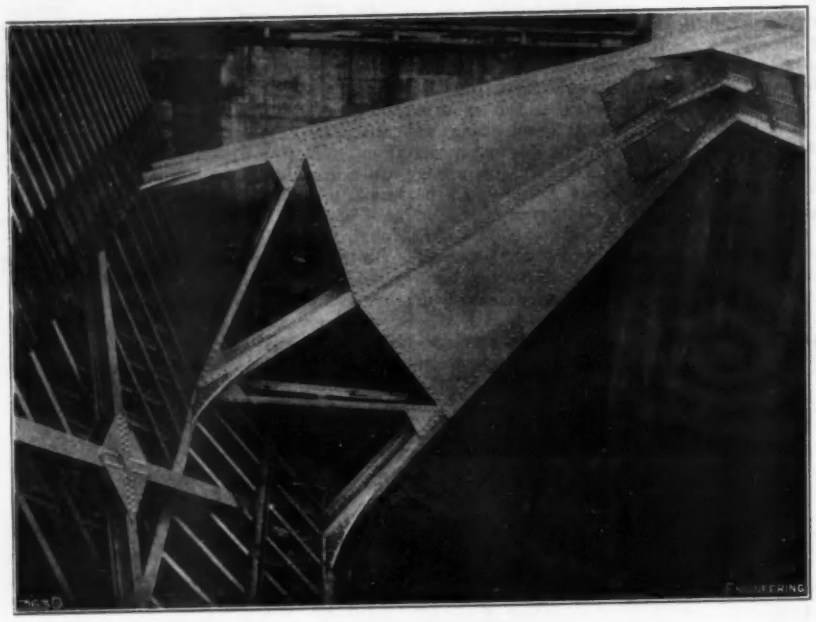


FIG. 3. SECTOR GATE.

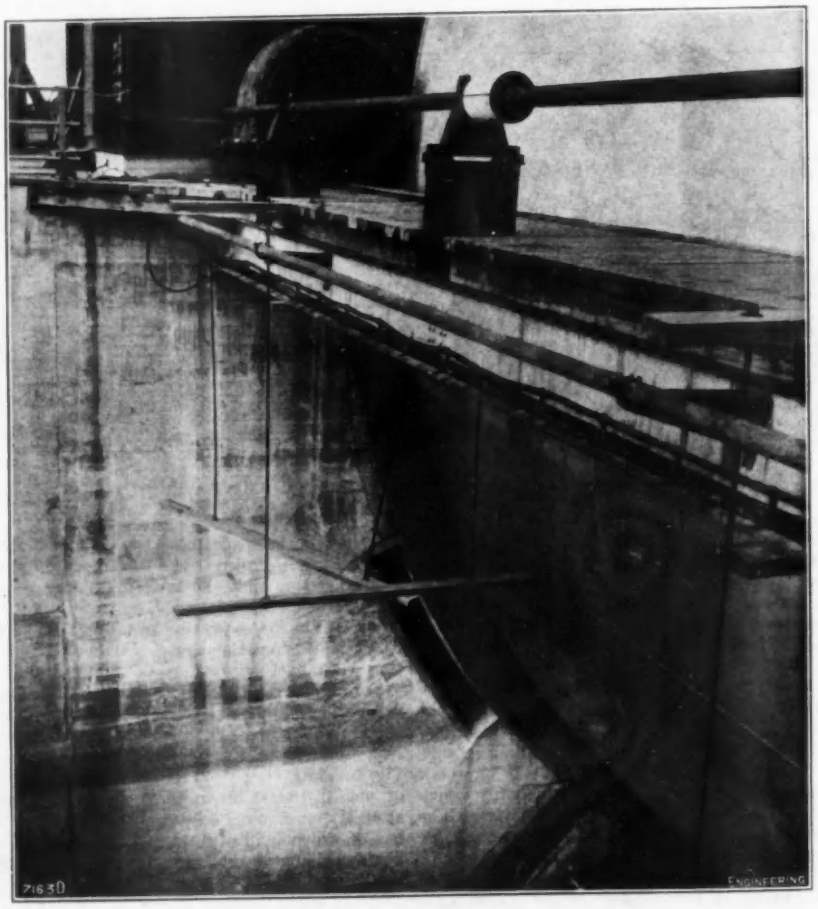


FIG. 4. SECTOR GATE SHOWING HOISTING DRUM.

THE VARGÖN POWER STATION, SWEDEN.

(*For Description, see Page 27.*)

Fig.5.

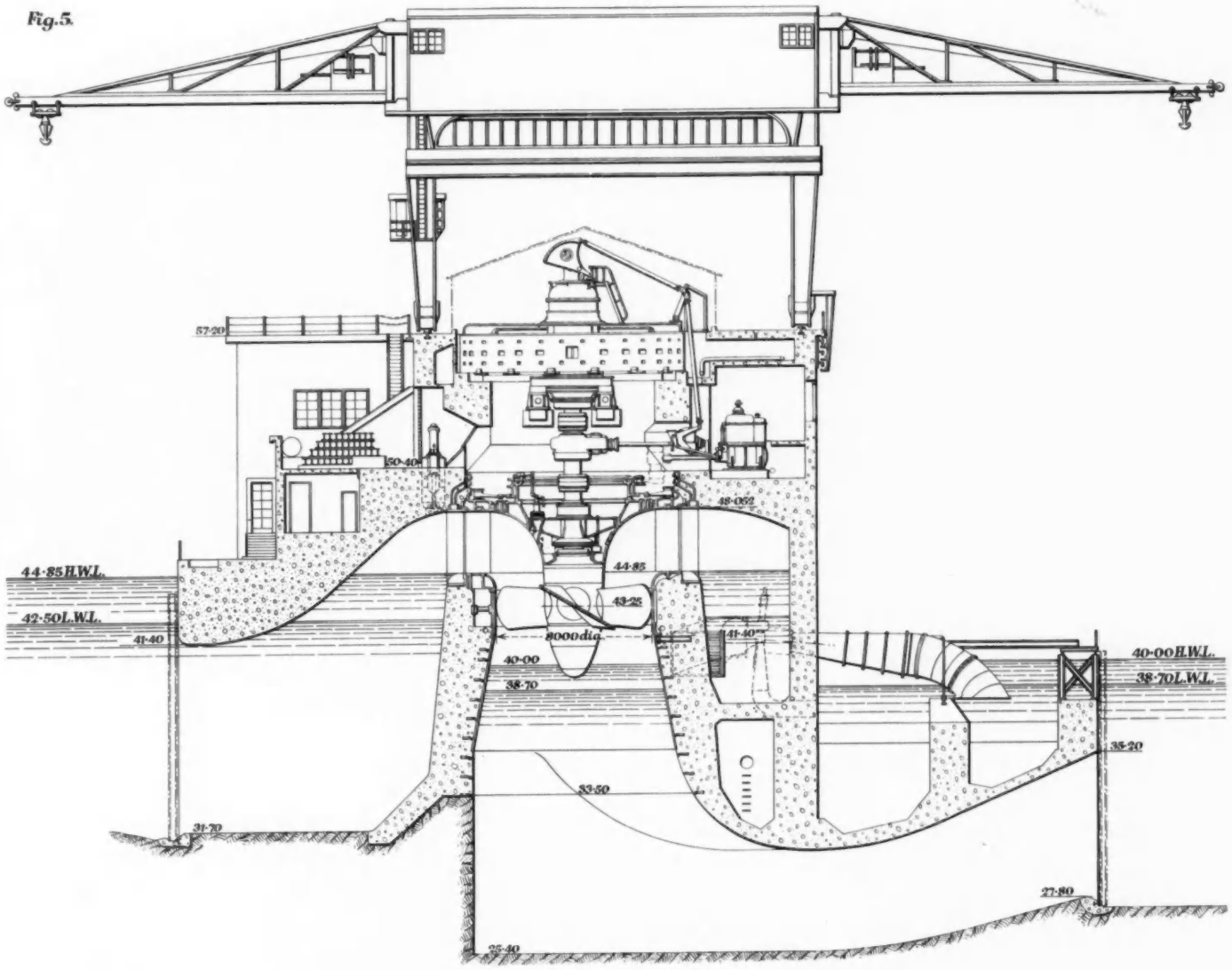
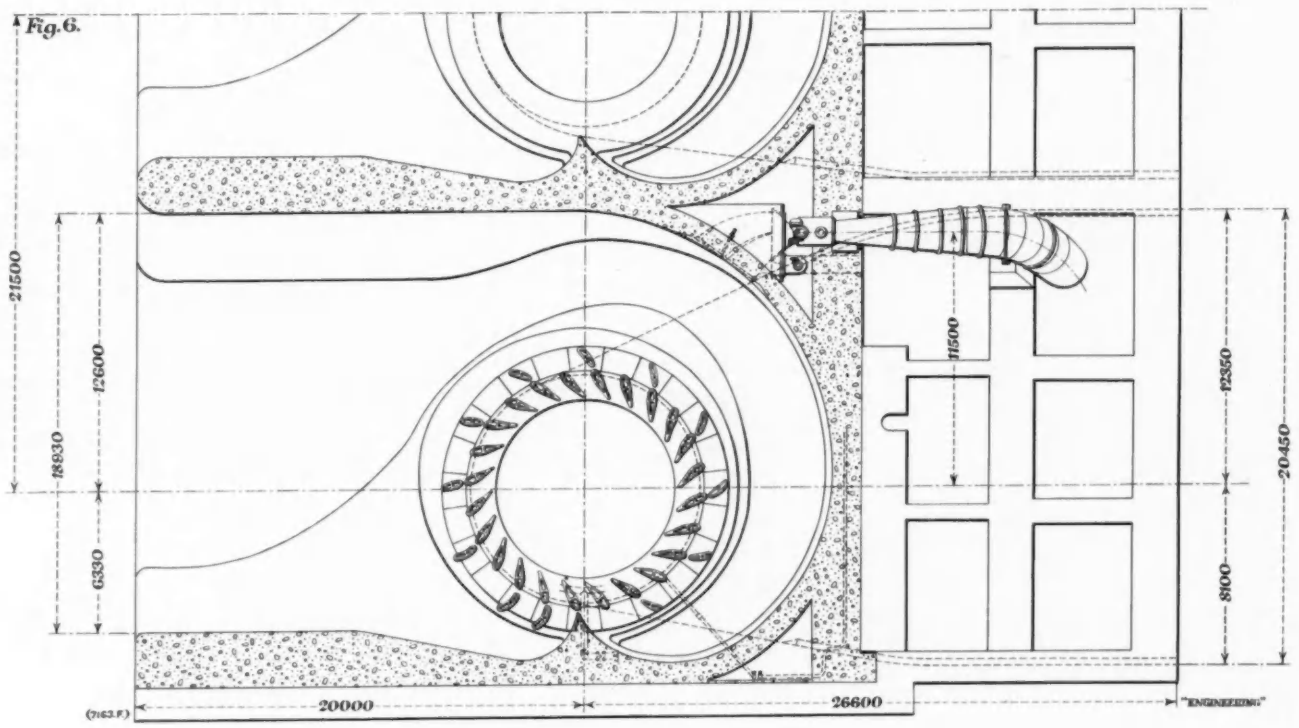


Fig.6.



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THE VARGÖN POWER STATION OF THE ROYAL SWEDISH BOARD OF WATERFALLS.

(*For Description, see Page* 27).

FIG. 7. ONE OF THE TURBINE RUNNERS.

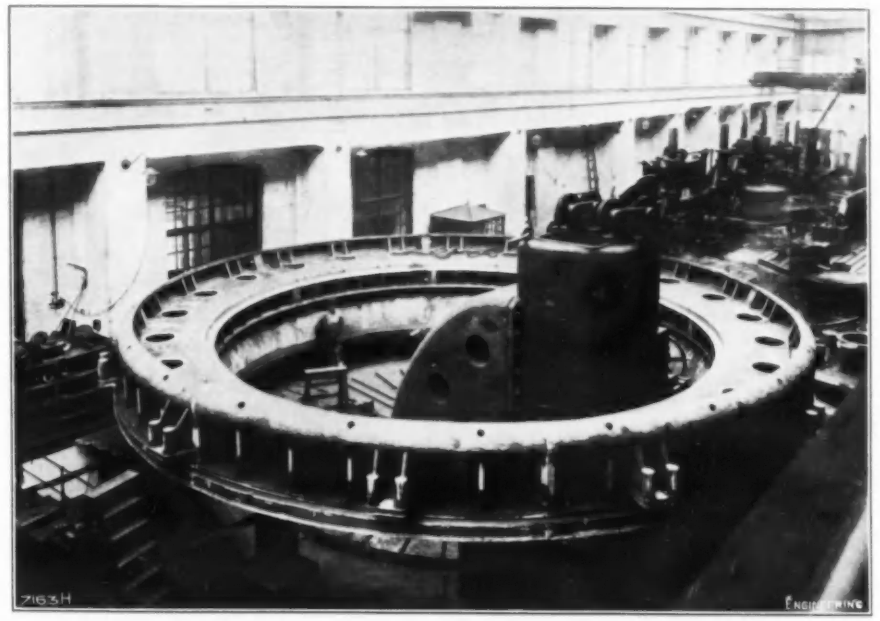


FIG. 8. UPPER AND LOWER GATE RINGS.

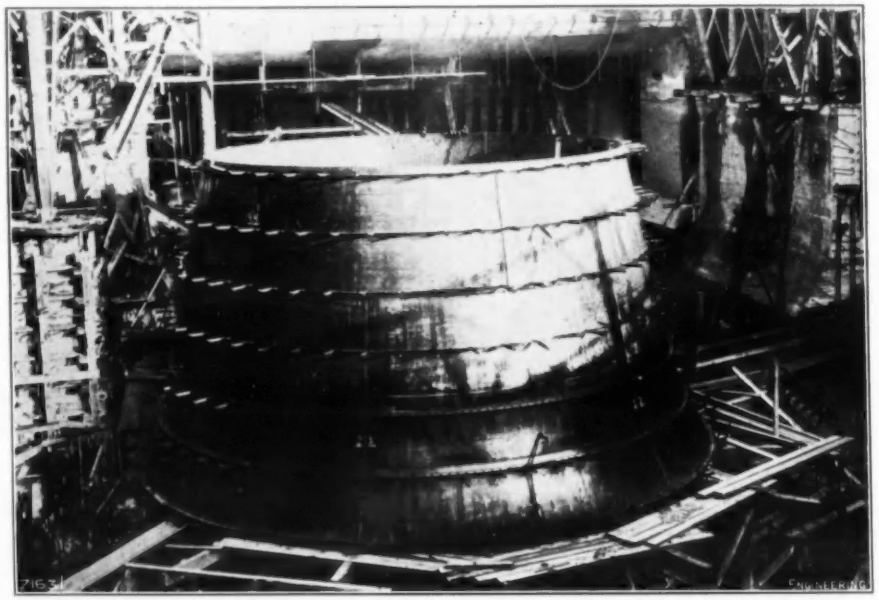


FIG. 9. DRAFT-TUBE LINING IN COURSE OF ERECTION.

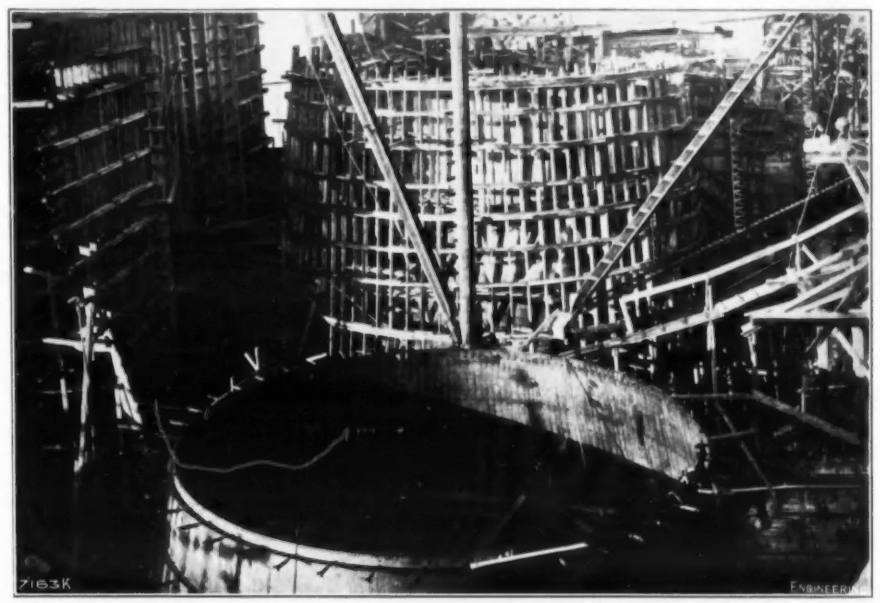
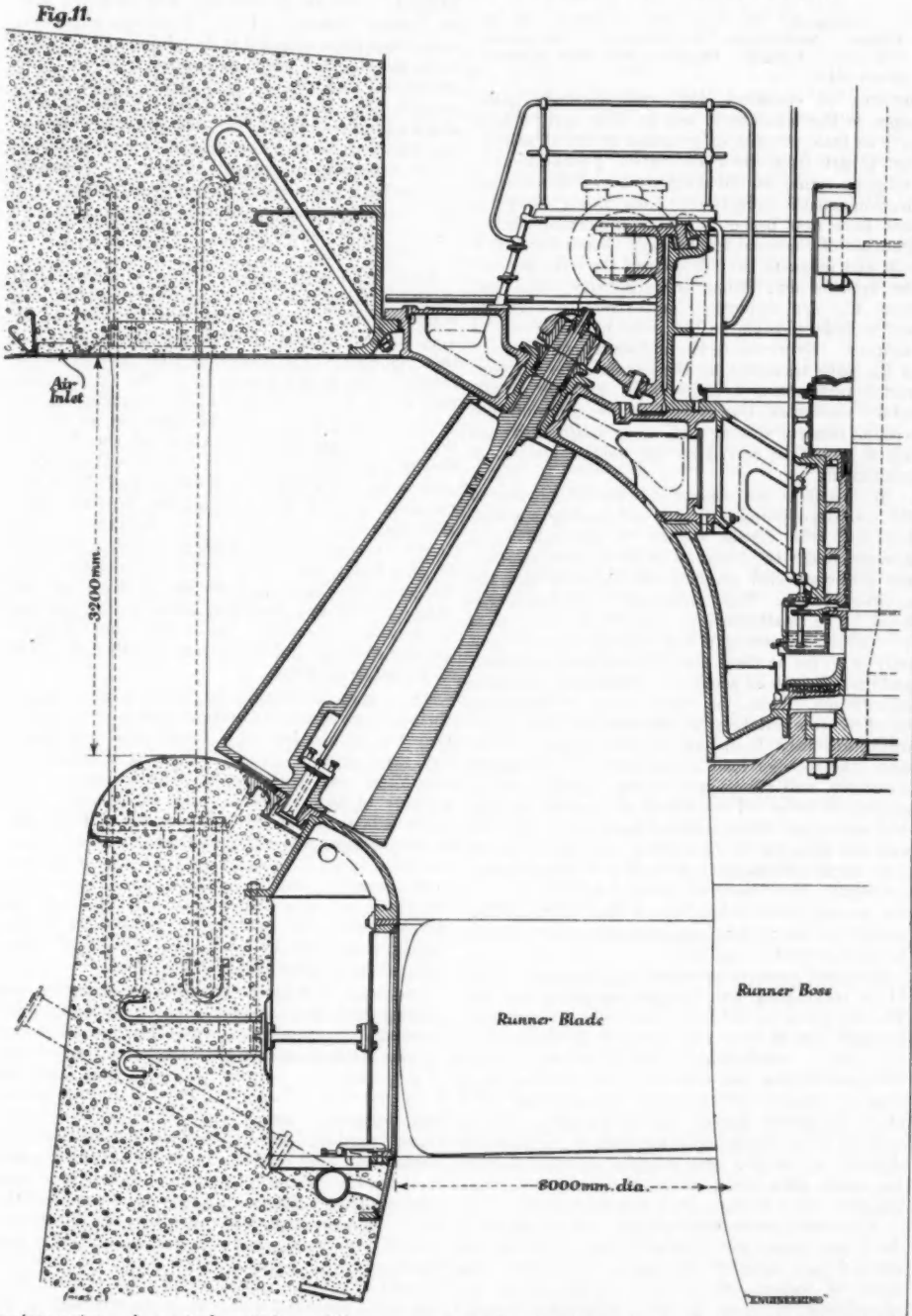


FIG. 10. DRAFT-TUBE LINING AND TIMBER SHUTTERING.

THE VARGÖN POWER STATION, SWEDEN.

Fig. 11.



sector gates. A control switch enabling remote control to be effected either from Trollhättan or Vargön is also provided. A similar control desk with mimic diagram and control switches is installed at Trollhättan.

Automatic control of the generator voltage is effected by a high-speed regulator working in conjunction with a high-speed booster exciter. The latter machine is a direct-current shunt motor and is supplied from a battery, thus rendering it unnecessary to use flywheels on the pilot exciters. The regulating rheostats can be remote-operated from Trollhättan. The generators are not remote-controlled and the units have to be switched in by the Vargön staff. A safety device is provided to prevent wrong synchronisation. This only allows the circuit breakers to be closed when the machines are practically in synchronism and the difference between the respective frequencies lies within a certain range. When synchronism is reached, this device closes the control circuit of the circuit breaker through a relay. Synchronisation is, therefore, carried out semi-automatically, the operator having only to adjust the governor speed and put the circuit breaker master switch in the closed position. The safety device then closes the circuit breaker at the right moment.

Each unit is provided with a number of electrically-operated auxiliaries for regulating the turbines. All this equipment, the functions of which will be clear from the following description of the operation of starting up, is mounted on a panel alongside each generator. As previously stated, the turbine gates are above the head-water level and the intake must be filled with water before the set can be started. This is done by extracting the air from the intake by means of ejectors. There are two ejectors on each turbine, one of which can evacuate the chamber in about 3 hours, while the former can be operated from the control panel, so as to start automatically when the water level in the intake begins to sink. The starter for this ejector is operated by a contact on a float-controlled rheostat. In practice, it has been found that any air which collects in the intake is carried away by the water, so that it has been unnecessary to use this apparatus. To enable the set to be stopped in case of emergency, the roof of the intake is fitted with two large doors, which can be opened or closed from the control panel. Opening these doors admits air to the intake and destroys the vacuum, so that the set is brought to rest very quickly.

When starting, the runner blades must be open and, as they are moved to the closed position when the set is shut down, means must be provided for moving them independently of the governor mechanism described above. This is effected by a motor which actuates the push rod of the mechanism independently of the dam. The turbine will start when the gates are open not much more than the amount required by the normal no-load setting. Once the turbine has started up, the control switch for the motor operating the governor mechanism is placed in the running position. This causes the starting equipment to run to its limiting position and stop, a condition which is indicated by a signal lamp on the control board. Further control of the runner blades is then effected by the control mechanism. To stop the turbine, the gates are shut and a catch closed, after which the switch on the controller is moved so that its motor turns the runner blades back into the position suitable for restarting. In this position the blades exercise a powerful braking effect. The control motor is brought to rest as before by a limit switch, its position being indicated by a lamp on the control board. Interlocking is provided to ensure the correct sequence of operations.

The oil to the servo-motor operating the runner blades is shut off by an oil-operated valve. The supply of oil to this valve is controlled by a magnetic valve, which is operated by push buttons on the control panel. If the pressure in the oil receiver falls below a certain figure, a switch is closed which energises both the magnetic valve just mentioned and the magnet used for closing the gates. The reason for cutting off the supply to the servo-motor operating the blades is that it requires a large supply of oil and it is essential that sufficient should be left in the main tank to enable the gate-closing mechanism to be operated. As already mentioned, the motor driving the governor head is supplied from its own generator, which is provided with protective devices to guard against a loss of excitation or a short-circuit in the connections. If one of these faults should occur, the protective relays energise a magnet, which locks the regulating slide of the governor, so that the gates remain in the corresponding position. A visual indication is at the same time given in the control room. When the fault has been removed, the relays return to their normal position and the regulating slide can be unlocked by depressing a push button on the turbine panel. This returns the magnet to its normal position. Over-speed protection is provided by a centrifugal switch on the exciter shaft causing the gate-closing magnet to operate. As a further safeguard in case of a fault in this centrifugal switch, the air valves, which are normally held shut by oil from the governor, are arranged to open automatically should that pressure fall abnormally low. A second centrifugal switch on the same shaft breaks the field circuit of the exciter if over-speed occurs, and this prevents overloading and undue stresses on the gearing and driving shaft. When the magnets for closing the gates or opening the air valves operate, the main generator breaker and exciter switch are both automatically opened. The differential relay on the generator also operates the gate-closing magnet, thus bringing the set to rest and at the same time releasing a stream of carbon dioxide. The setting of the turbine governor can be adjusted by motors which are remote-controlled both from Vargön and Trollhättan. The water level in the turbine inlet is indicated by a float-operated rheostat. This is fixed at the top of a stand pipe, which is brought out from the turbine-chamber on the down-stream side.

Owing to the comparatively large number of different readings which have to be indicated continuously at Trollhättan, a system of remote-control making use of alternating current at two different frequencies, as well as direct current, was adopted. The multi-core cable used is paper-insulated, lead-sheathed and steel-wire armoured, and is made up of five twin conductors, 2 sq. mm. by 1·5 sq. mm. in section, 38 1·5 sq. mm. single conductors and a 6 sq. mm. neutral. Three of the five twin con-

ductors are used for telephony and the others carry alternating current for metering the frequency and voltage of the generators. In the middle of the run, which is 13,445 m. in length, the conductors are transposed to reduce the inductance.

The operation and supervision of the position of the generator breakers, but not their control, is effected from Trollhättan. In addition, there is supervisory control of the transformer tap changers, the sector gates, the turbine-gate opening, the governor, and the voltage regulator on each unit. The water level in the turbine intake and the head- and tail-water levels at Vargön are also registered at Trollhättan. Signals are, moreover, transmitted to Trollhättan when the water level is too low in the head race and when the temperature at any of the measuring points on the units is exceeded. The control impulses are sent out by alternating currents at frequencies of 37·5 cycles and 62·5 cycles, respectively. These currents are generated by a small frequency changer installed at Trollhättan, consisting of a 190-volt 25-cycle synchronous reaction motor, which is coupled to a generator with two windings. This generator, which is designed so that it can be provided with five windings, drives a two-way switch through reduction gearing. This switch makes and breaks the direct-current through the signal lamps, so that a regular train of flashes is given. There is a similar frequency-changer set at Vargön for sending signals to Trollhättan. This is driven from the local 25-cycle network. The remote-control equipment also includes a battery, consisting of two groups of 50 cells, across which a metal rectifier is connected. These rectifiers are supplied with 25-cycle current at 190 volts, and are normally used to supply direct current for the remote metering circuit. By connecting a separate rectifier across each half of the battery, the supply is unaffected by unequal loading on the two halves.

Each main circuit breaker is remote-controlled by two alternating-current relays, which are connected, respectively, to the 37·5-cycle and 62·5-cycle circuits. These relays close the circuit of an intermediate relay, which, in turn, closes the tripping coil or closing contacts. When a breaker trips, signal lamps and an alarm bell are actuated at Vargön and Trollhättan, the bell continuing to ring until the handle of the control switch is placed in the position corresponding to that of its circuit breaker. It is claimed that this system of control can be operated even when the frequency of the control voltage varies beyond the limits of + 8 per cent. and — 4 per cent. The circuit breakers can be operated in this way either from Trollhättan or Vargön, the change-over from one to the other being effected by a switch which causes appropriate signal lamps to be lighted and audible signals given. Generally speaking, the control is centred at Vargön, which can take over from Trollhättan in any circumstances. It is thus able to take control without having to wait for permission, and, if necessary, can block the remote control of a particular breaker, or of the whole system. Voltage and frequency readings are transmitted through a voltage transformer at Vargön and a pair of twisted conductors to a voltage and frequency meter, which are connected in series at Trollhättan. The indicating of the turbine and sector gates, as well as the water level, is effected by potentiometer rheostats. Similarly, the indication of useful and wattless power is transmitted by a motor-operated potentiometer and balanced relay, the power to be measured acting on one side of the relay arm, while the other is balanced by a direct-current coil energised from the potentiometer.

LETTERS TO COMMERCIAL DIPLOMATIC OFFICERS.—United Kingdom firms, when addressing applications for assistance to H.M Commercial, Diplomatic and Consular Officers overseas, are asked to enclose a duplicate copy of their letters, in order to simplify and expedite the work of dealing with them under war conditions.

CLOSING OF THE BARMEN-ELBERFELD RAILWAY.—It is reported from Holland that the railway between Barmen and Elberfeld, which was opened in 1901 and, it will be recalled, is worked on the mono-rail suspension system, is to be closed because of "technical disturbances." The line serves a busy district in the Ruhr.

LITERATURE.

The Fundamental Theory of Arc Converters. By H. RISSIK. Monographs on Electrical Engineering. Vol. VIII. London: Chapman and Hall, Limited. [Price 18*s.*]

STUDIES of electrical discharges through gases began in the laboratory, and in their early stages gave as little promise of eventual technical utilisation (apart from their decorative possibilities in luminous signs) as did Faraday's experiments on electromagnetic induction. Like them, however, they have now become of basic importance in all branches of electrical technology. From Faraday's coils and magnets have developed the dynamo and the transformer; from the discharge tube has come the arc converter, an extremely versatile and flexible addition to the plant of the electrical engineer. By virtue of the unilateral conductivity of the path traversed by the current, the arc converter performs a function akin to that of the rotary converter, but it can secure commutation without relative motion, and can be adapted to ends which cannot be served by the more conventional equipment.

Mr. Rissik is not concerned with the physics of the discharge process, already adequately covered, but with the circuit theory of arc converters, grouped under the headings of the normal rectifier, the grid-controlled rectifier, the inverter and the cyclo-converter. The treatment throughout is lucid. The mathematical analysis is kept clear by considering essentials first, adding complications only in so far as these are of practical significance, and excluding those which are of subsidiary practical importance. Thus, in the ideal arc-discharge rectifier, commutation is assumed to take place instantaneously from one rectifier phase to the next, the rectifier load is assumed to be infinitely inductive, and the supply voltage is taken to be sinusoidal under all conditions of rectifier loading. Not until the voltage, current and power relations, and the presence of harmonics resulting from the wave-form distortion characteristic of static current conversion have been established for this case, is the investigation taken up of the corresponding quantities for circuits approximating more closely to those actually employed.

A similar mode of progression is adopted in Part II, in connection with the grid-controlled rectifier. The full resources of the arc converter are strikingly brought out in Part III, where it is shown how, by suitably combining the rectifier and inverter functions of the arc converter, the equivalent of either a static direct-current transformer or a static frequency changer can be obtained. Tables, such as those appearing at the ends of the chapters devoted to simplex and complex rectifier circuits, in which data deduced in the course of these chapters are collected, are a helpful feature.

A comprehensive bibliography follows the text. In it, the papers are grouped under years, and are divided into those of English (or American), and those of foreign origin. To the list given, the monograph of Giroz, in the "Collection Armand Colin," might usefully be added. The book is commendably free from misprints. In the expression for μ, on page 94, $\frac{I}{I_0}$ should be inverted; and, in the top line of page 118, $\frac{2}{\pi}\sin 4\ \theta$ should read $\frac{2}{\pi^2}\sin^4\theta$, while on page 241, "are" appears in place of "arc." This work of Mr. Rissik fills a gap in the existing literature, and fully maintains the standard set by previous volumes in this useful series of monographs.

Land Drainage and Reclamation. By PROFESSORS Q. C. AYRES and DANIELS SCOATES. London: McGraw-Hill Publishing Company. [Price 26*s.*]

THIS volume, the second edition of a book originally published in 1928, is a valuable study of the work of the land-drainage engineer. Written by members of the educational staffs of the Agricultural Engineering Departments of Iowa and Texas State Colleges, it combines both theory and practice in a useful and compact form. It is refreshing to read the tribute, in the introduction, that "The two spectacular accomplishments of the Old World most frequently quoted by drainage authorities are the Fens of England and Haarlem Lake of Holland." Future generations will probably add the Pontine Marshes in Italy. To British engineers, apart from those engaged in Dominion and Colonial work, the chapters which will appeal most are those on rainfall and run-off, open ditch design, maintenance, etc., and those chapters devoted to problems of under-drainage, or "tile drainage," to use the American term. The subject of land drainage is an especially important branch of American engineering; the authors mention that, in spite of flood control, in one year (1912) losses amounting to approximately 50,000,000*l.* sterling were caused by flooding in the United States.

There has been a certain amount of controversy, among British drainage engineers, regarding the definition of "run-off." One that appears to be very suitable is that of Professor Mead, quoted in this volume: "The run-off is that portion of the rainfall that is not absorbed by the deep strata, utilised by vegetation or lost by evaporation, and which finds its way into the streams as surface flow." An appreciable portion of the book is devoted to the study of so-called "soil erosion," now menacing agriculture in the United States and Canada, and of first importance to the whole American Continent, especially the prairie lands. It is to be regretted that more attention is not given to the design and construction of outfall sluices, less than two pages being devoted to this important subject. This may, however, be due to the fact that most ultimate outfalls in America are pumped, gravity drainage not being largely adopted, except to pumping chambers.

There is an interesting chapter on explosives and their use, in which the authors express the opinion that "it is not advisable to attempt blasting in dry sand or thin muck." Blasting channels has not often been tried in the British Isles for the purpose of land drainage, and an attempt, some years ago, to divert the entrance of the River Alt, in Lancashire, was a failure; that was in "sand and thin muck." Terracing of hillsides is exhaustively treated, and presents an interesting study for those not acquainted with this type of land development. A noteworthy innovation is the ingenious machine known as the Whirlwind rotary terracer, particulars of which are given.

The book is well illustrated with diagrams and photographs, and includes some valuable formulæ, especially in connection with the flow of water in open earth channels; the design of these channels is ably discussed. The writers have gone far afield to gather their information, but the average reader will probably consider that some of the "class room" matter of an obviously elementary character might have been omitted, being rather out of place in a treatise primarily addressed to the practising land-drainage engineer. It may be noted that the word "reclamation," in the title, is apparently intended to cover only the reclamation of waste lands and their agricultural development, and the control of rivers. Direct reclamation of land from the sea is not dealt with, except superficially in the introduction.

The Quality of Coke. By DR. R. A. MOTT and PROFESSOR R. V. WHEELER. London: Chapman and Hall, Limited. [Price 36*s.* net.]

IN 1930, the Midland Coke Research Committee published, under the signatures of these authors, an account of their research work up to 1929. This present volume is the second such report and carries the researches from 1929 to 1937, with some account of subsequent work. The recent death of Professor Wheeler has deprived the Committee of their guiding hand, and it is fitting that this summary of the work for which he has been responsible, as the honorary Director of Research to the Committee, should have appeared at this time. The publication is in no sense a text-book, but is a plain record of research work and of the conclusions that have been drawn from it. A long and important series of researches has been devoted to developing standards for commercial metallurgical coke, this work having involved a consideration of the importance of certain characteristics of coke in the blast-furnace, and a very exact and

painstaking investigation of the methods by which these qualities can be determined experimentally. Sampling is the first major difficulty to be overcome, but there are in this section equally detailed reports upon density and porosity, abradability, hardness and reactivity. It is of interest to observe that the authors appear to have changed their earlier views and are now seen to be on the verge of agreement with Koppers in ascribing importance to the property of combustibility of coke, even in the blast-furnace. As a result of these investigations, the Midland Coke Research Committee have drawn up a scheme for the sale of coke to specification, which is described in considerable detail.

It would appear that this work, and some researches upon the mechanism of coke formation, have occupied the major portion of the energies of the research staff since 1929. Time has been found, however, for a continuation of work, described in the first report, upon the improvement of Midland cokes for blast-furnace purposes. It is found that fine-grinding coals of poor coking qualities leads to improved coke, a conclusion in agreement with existing practice. The importance of low ash content, and of absence of shale, is also confirmed. The authors re-affirm their earlier conclusion that cake-charging of coke ovens should be abandoned, save in exceptional circumstances; this view also is accepted fairly generally, because top-charging leads to greater output per man employed. The importance of proper blending of coals and of blending with durain and fusain, or of using coals containing adequate quantities of durain and fusain, is stressed once again. This was, perhaps, the outstanding contribution to scientific knowledge of the Midland Coke Research Committee, the opinion generally held before the committee started operations being that, the greater the quantity of "coking constituents" (usually considered synonymous with bright coal), the better the coke. So far, it has proved impossible to forecast the consequences of blending two or more coals, from the known behaviour of the individual coals. It will be realised that this is a volume of researches which the authors summarise as follows in their concluding sentence: "The data at present available, collected during several years of patient and systematic research work, are insufficient to give more than pointers to the truth." In some directions, that remark (made with specific reference to blending) is generally true of the book, but in others, the researches described have completely elucidated the facts; this is particularly true, perhaps, of the work on the methods of testing cokes. As a reference volume, the compilation is one of notable value.

Det Norske Veritas: Beretning til 75 Årsjubileet, 1939. (The Norwegian Veritas: Report for the 75-year Jubilee, 1939.) Oslo: C. C. Werner and Company.

THIS commemorative volume is of particular interest at the present time. In the first place, it shows the important standing of the Norwegian marine, and secondly, being a supplement to the similar volume which was published in 1914, on the occasion of the 50-year jubilee of the Norwegian Veritas, it brings out clearly the effect of the Great War and the recovery thereafter. The first section deals with the history of the organisation during the past twenty-five years, the development of the Norwegian merchant marine during the same period, and the relation between the two. Fifteen pages are devoted to the subject of marine-engine developments. The second section deals with the personnel and constituents of the Veritas from the beginning, and the third gives a corresponding list for the present year.

The concluding section is statistical. The Norwegian merchant fleet, from 1864 to 1939, is analysed into steamships, sailing ships and motor-ships, each by annual number, total gross tonnage and mean individual tonnage for the year. A further analysis is given, from 1914 to 1939, into cargo ships, tankers, passenger ships, fishing vessels, whale-factory ships and auxiliary craft. The figures show that the total tonnage had risen from about half a million in 1864 to over 4½ millions in 1939. Whereas, in 1890, almost all the tonnage was sailing, there are now only three sailing ships, with a total tonnage of 950. Motor-driven tonnage has risen from nothing in 1913 to nearly three million tons, while the steam tonnage, which was 2,400,000 in 1932, has now dropped to about 1,800,000.

The next table shows the annual changes in tonnage due to building and purchase, less losses and sales, since 1914. It is interesting to notice that, in the war years 1916, 1917 and 1918, there were losses of 26,000, 632,000 and 163,500 tons, respectively. Table 3 shows the ships built for Norway during the past 25 years, both at home and abroad, analysed according to steam and motor drive, and steel or composite construction. Tankers are shown separately. The concrete ships of 1917 to 1921 are tabled, as well as a few wooden ships. Table 4 gives the registrations of Norwegian and foreign ships with the Norske Veritas, from which it appears that nearly half the Norwegian tonnage is so registered.

As before the Great War, Norway remains the fourth of the seafaring nations, Great Britain, Germany and the United States occupying the first three places. In the years between, the fourth place has been held by other nations, but Norway has recovered it. In 1939, Norway's shipping (1,977 ships totalling 4,658,593 tons gross) was 6·38 per cent. of the world's by number and 6·87 per cent. by tonnage, as compared with 7·11 per cent. and 5·22 per cent. in 1914. Losses during the Great War were more than a million tons, showing a remarkable recovery. During the years 1914 to 1938, 1,720 ships were built for Norway, totalling 4,545,365 tons gross. The United Kingdom produced 298 of these, with a tonnage of 1,229,222, Germany and Danzig 95 ships with a tonnage of 570,000. Norway, Sweden and Denmark each contributed about three-quarters of a million tons. An interesting fact brought out in the figures is that the annual loss (war losses excluded) by number has been reduced to about 1 per cent., whereas in the lustrum 1897 to 1901 it was 5·9 per cent. This is partly attributable to the reduced proportion of sailing ships. The relation between Scandinavian and British shipping has always been very intimate, as may be seen by perusing the pages of Hakluyt. Our Viking ancestors have worthy descendants in their home lands and it is hoped that the co-operation and friendly rivalry may long continue.

THE IMPERIAL INSTITUTE AS AN INFORMATION CENTRE.*

By SIR HARRY LINDSAY, K.C.I.E., C.B.E., Director of the Imperial Institute.

I HAVE been asked to give some account of the work of the Imperial Institute; and, indeed, I know of no institution better qualified to furnish material for just those studies which are germane to the work of this Association, for the Institute is itself, on its scientific and technical side, an Information Bureau, with interests which are Empire-wide and sources of information which are world-wide. Moreover, it possesses a Library which is "special" in the sense that it caters for specialists in the technique of raw materials, their sources, production, processing and trade. The raw materials we are called upon to handle and advise upon are of Empire origin; yet we must also keep an eye on those of foreign origin, for comparative and competitive purposes. We are also called upon to furnish general information about the Empire, particularly its geography and its economic products, and chiefly for the use of schools.

The Imperial Institute was founded in 1887, and completed in 1893 as a national memorial of the Golden Jubilee of Queen Victoria. Not only the United Kingdom, but also many countries of the Overseas Empire, contributed the 400,000*l.* required for its construction and endowment. King Edward VII, then Prince of Wales, was the first President of the Institute, which, in his own words, was intended "to promote the utilisation of Empire products and to make better known the life, resources and the industries of the various countries which comprise the British Empire." This primary character of a clearing house of information about the resources of the Empire, the Institute has never lost. The following is an account of the actual tasks set before us, as summarised in the Imperial Institute Act of 1925:—

(1) To promote the commercial, industrial and educational interests of the Empire.

(2) To collect and disseminate the following classes of information:—

(*a*) Possible uses of and markets for new raw materials.

(*b*) New uses of and markets for raw materials already known.

(*c*) Sources, production, supplies, cost, consumption and requirements of raw materials and legislation relating thereto.

(*d*) The best means of increasing supplies or of creating new sources of supplies of raw materials within the Empire.

(*e*) The best means of treating them and of preparing them for marketing.

(*f*) Technical and scientific information bearing upon the industries of the Empire.

Throughout, the term raw materials is held to cover also semi-manufactured products. It is only when we come to sources of supplies of raw materials and information about industries that the scope of the information is limited to the Empire. This limitation is quite natural. Information about raw materials is received from all sources, both Empire and foreign, but is to be applied in the interests of the development of the resources and industries of the Empire.

(3) To advise on the development of the resources of the Empire in raw materials in order that such resources may be made available for the purposes of industry and commerce and of Imperial defence.

Here the question of Imperial defence is mentioned for the first time and is brought definitely within the scope of objects before the Institute.

(4) To conduct in the laboratories of the Institute preliminary investigations of raw materials and when it may be deemed advisable to arrange for more detailed investigation by appropriate scientific or technical institutions.

This is important. It means that we are not called upon to undertake research, but to carry out investigational work of practical value in the execution of the duties assigned to us. Requests for research are passed on to institutions competent to undertake it.

(5) To collect samples of raw materials having a definite value in industry and commerce; and

(6) To co-operate with other agencies within the Empire formed for similar purposes.

These two duties are consequential and obvious. The second one means that we maintain close contact with technical departments of Governments and Administrations throughout the Empire. Those which concern us most closely are naturally those which deal with Agriculture, Forestry, Fisheries, Veterinary Science, Geological Surveys, Mining, and Chemical Industries. Technical officers of the Overseas Empire, home on leave or deputation, are always invited to visit the Institute. We find these visits most helpful and the officers themselves are understood to benefit by the knowledge they thus gain of the facilities available to them in the Laboratories and Information Offices of the Institute.

(7) Finally, to maintain for public information and instruction in the Exhibition Galleries of the Institute exhibitions illustrative of the resources and development of the Empire and of its life, scenery and progress and where practicable to organise from time to time temporary exhibitions of a similar nature elsewhere.

So far as the actual task of administration is concerned, this is defined in terms of the Imperial Institute Act of 1925. We are not a Government Department but an institution responsible to Parliament through the Department of Overseas Trade, whose secretary, the Rt. Hon. R. S. Hudson, M.P., is President of our statutory Board of Governors, while Sir Quintin Hill, K.C.M.G., O.B.E., the Comptroller-General of the same Department, is vice-president. Representatives of the Treasury, Board of Trade, Colonial Office, Ministry of Agriculture and Fisheries and of the Department of Scientific and Industrial Research are Governors; also representatives of the Dominion and Indian Governments and of scientific and commercial interests. I was appointed Director nearly five years ago. Our finances are derived from contributions made to us annually by the United Kingdom, Dominion, Indian, Burma and Colonial Governments. The Indian States of Hyderabad, Mysore, Travancore and Cochin also contribute.

We are chiefly concerned to-day with the technical and scientific aspects of our work. From this point of view, the Institute may be regarded as a great Information Bureau with a staff of some 40 scientists. For the sake of convenience, the Bureau is divided into two main departments, one to handle enquiries relating to Plant and Animal Products, and the other Mineral Resources. Each Department has its own laboratories, intelligence offices, and indexing staff. There is a single Statistical Section serving both departments. The Library also serves both departments, although for the sake of convenience the volumes dealing with Mineral Resources are kept separate from those in our general Library. This arrangement is due to the fact that the old Imperial Mineral Resources Bureau,

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* Presidential Address prepared for presentation at the 16th Conference of the Association of Special Libraries and Information Bureaux at Nottingham. Abridged.

organised as a separate entity in 1919 as a result of lessons gained from the experience of the Great War, was amalgamated with the Institute in 1925 to form the nucleus of our Mineral Resources Department, and has retained its own separate library ever since.

But before I describe the scope and objects of the Library, let me first say something of the Institute as an Information Bureau. It is the Library, after all, which serves the Bureau rather than the Bureau the Library. Although the primary function of the Institute is that of an Information Bureau, I am straining a good deal the meaning of the word Bureau in applying it to the Institute. Imagine a Bureau which has its own laboratories, its own compilers and its own publications; and you will realise at once the risk of misunderstanding. In common parlance, a bureau is the kind of office which collects and disseminates information—a sort of "broker" among offices, which puts the seeker for information in touch with sources of supply. But we are not just brokers, we are not even just merchants, for we are busy also creating from our own investigations results which we pass to the client who asked for the investigation to be done and who in nine cases out of ten sent us the materials to be analysed or tested; results which we also store in our records and, if worth while, publish in our monographs or in our quarterly *Bulletin*, to be dispensed to other enquirers should the latter materialise. I don't say that some of this information specially collected in response to special demands is not kept confidential. It certainly is, at request. But requests for results to be kept confidential are on the whole uncommon; and most of our results are of a character which is not confidential.

I hope I have not emphasised our laboratory work unduly or given the impression that most of our enquiries involve chemical tests. That is by no means the case, for by far the greater proportion of our enquiries are simply for information regarding raw materials, their qualities, prices, supplies and demands, markets, and so on; it is the minority which come linked with a particular specimen or sample demanding chemical investigation or mechanical test in our laboratories. The enquiries come to us from a very wide variety of sources. It may be the technical department of a Government of the Empire—Home or Overseas—it may be farmer or planter of the Overseas Empire, or a mining or timber concessionaire who is anxious for help to market his produce; it may be a merchant or manufacturer in this country who has hitherto handled produce of foreign origin and wishes to tap new sources of supply within the Empire; it may be a scientist or consultant who wishes to know if our results coincide with his own. The character of the enquiries varies within a wide range. Sometimes it is a request for identification; or we may be asked to what uses certain products are put, or for advice as to new uses, advice as to the best kind of machinery for processing, or the best method of packing; or again for advice as to new sources of supply within the Empire. Let me add, by way of illustration, a list of some of the raw materials with the countries concerned, dealt with at the Imperial Institute during the past month:—Cassava products from St. Lucia; Vanilla from Grenada; Preserved Ginger from Jamaica; Citrus and Pineapple Juices from Nigeria; Grape-fruit juice from the Gold Coast; Cashew nuts from Ceylon; Drug cultivation from Kenya; Cinchona from British Honduras; Tung nuts from the Union of South Africa; Tobacco extract from Southern Rhodesia; Mangrove wood for paper-making from Tanganyika; Beeswax and Eucalyptus oil (the latter for ore flotation) from Northern Rhodesia; Radium minerals from Canada; Iceland Spar from the Union of South Africa; Titanium white pigment and clay for aluminous cement from Ceylon; Diatomite and Asbestos rock from New Zealand; a rare mineral from the Gold Coast; Electromagnetic separation of minerals from the Federated Malay States; Building stones from Nigeria; Chromite from Sierra Leone; Vermiculite from Tanganyika; Bituminous material from Palestine.

How do we get the information to answer these widely varying questions relating to widely different products? First and foremost from the accumulated experience of nearly fifty years of such work at the Institute. I think it can safely be said that no other body doing work of this nature can claim such a long record. The next important thing is personnel. We have still on our staff highly trained scientific officers who have been engaged in these tasks for thirty or thirty-five years. Such experience is obviously of inestimable value. Our staff comprises university graduates either with training in one of the fundamental sciences concerned with economic products, such as chemistry and botany, or mineralogy, or with commercial or industrial experience.

In carrying out these investigations we have the help of two Advisory Councils, one on Plant and Animal Products with Sir Frank Stockdale, K.C.M.G., as its chairman, and one on Mineral Resources under Sir William Larke, K.B.E. The two Councils control the activities of 15 Consultative Committees dealing with the following major groups of raw materials:—Timbers, vegetable fibres, oils and oilseeds (with a sub-committee on tung oil), essential oils, gums and resins, tanning materials, hides and skins, and insecticide materials of vegetable origin; and on the minerals side—Precious metals, base metals, coal and petroleum, iron and ferro-alloys, chemical industries, miscellaneous minerals, and mining law. On these Councils and Committees, the United Kingdom, Dominion, Indian and Colonial Governments are represented, as well as commercial and industrial interests and scientific circles. Thus business men, scientists and administrators meet in our Conference rooms and discuss with us the various technical problems which reach us from all over the Empire; they also assist us from time to time with information and material required to enable us to compile and publish our technical monographs and our quarterly *Bulletin*. Technical officers of Overseas Governments are also invited to attend our committees when their own problems are under discussion. This is team work of a high order, and, without the help of these teams we should find it difficult or impossible to meet from our own technical experience and skill all the demands made upon us. I should add that, in all our scientific and technical work, we co-operate closely with the High Commissioners and with the Colonial Office, and, on the marketing side, with the Colonial Empire Marketing Board.

I now turn to describe the work of our Special Library. Before the war, it was fairly easy to maintain a library such as ours. The kind of technical works which we had to acquire were not nearly so numerous as they are now; and, above all, the number of technical journals (as distinct from text-books) was much less. Nowadays the balance has shifted. We are forced to rely more on journals and less on books. The fact is that as science advances it is bound to become more and more departmentalised, for only by means of increasing specialisation can the intelligence of man grapple adequately with the scientific problems which his own intelligence has raised. The result is that whereas, before, our scientific staff had to read widely amongst scientific books of reference, nowadays they have not only to read such books, but also to keep abreast with the latest articles in technical journals; not only journals in English, but in foreign languages as well. The method employed is to circulate the journals amongst the staff, each member concentrating on those which bear on his special subjects, and marking the articles which are likely to be of more or less permanent interest. After the journals have been marked they pass to our indexers, who have to be fully qualified both technically and linguistically for their work. They enter the references in the card-index and also, from their own technical knowledge, and from the monthly abstracts of current work, enter up any other articles, not marked by the laboratory or intelligence staff, which are likely to be useful. Our card index, which for the convenience of the staff is arranged under subject headings, by commodities, was begun some forty years ago, and the mass of information which can thus be made available at short notice is amazing.

The *Bulletin*, which contains articles and notes summarising the results of investigations carried out in our laboratories or of trade enquiries which we have dealt with, as well as technical reports of Empire or foreign sources, has for thirty-six years served as an invaluable means of disseminating information about commercial products of the Empire; the extensive bibliographies which it provides are of great value. In addition, the technical monographs compiled at the Institute provide detailed information of the classes of products which form the basis of our work. Our mineral monographs, over 50 in number, are revised and more usually completely re-written from time to time as required. Each volume of this series deals with a particular mineral or with the ores of a particular metal or with a group of minerals of similar application, such as gemstones or abrasives. On the plant and animal products side, we have recently published a monograph on the preparation of hides and skins of the Empire, and we have almost ready for publication a monograph on insecticide materials of vegetable origin.

As an indication of the scope of our Special Library and Information Bureau, let me quote the following figures:—The total number of books in our library is 75,250 volumes. We acquired last year, by purchase or gift, of books and other non-periodical publications, 4,170 volumes. We receive each year 900 periodicals, comprising altogether some 26,000 separate issues. Of the 900 periodicals, the number of dailies and weeklies is 150, of which nearly one-half are United Kingdom in origin, nearly one-third Overseas Empire, and nearly one-quarter Foreign. Of the 600 monthlies and quarterlies, nearly one-third are United Kingdom, nearly one-third come from the Overseas Empire, and over one-third are foreign. Finally, we receive a number of miscellaneous periodical publications, *e.g.*, all the annual reports of the Dominion and Colonial Governments, and their Gazettes, as well as many market reports, both British and foreign.

Statistics play an important part in our work. We have a special section for this work, which ensures that all doubtful statistics are closely scrutinised before being accepted, for there is nothing more misleading than undigested statistics. Not only do we collect and collate from the annual returns received from official sources, but we also secure many interim statements which are of considerable service to the Institute and its inquirers particularly, as the printed annual statements do not reach us until many months after the close of the year. Our most important piece of statistical work is the production of our *Annual Statistical Summary of the Mineral Industry of the British Empire and Foreign Countries*. This annual volume of about 450 pages gives the production, imports and exports of most minerals and metals throughout the world, and has, I think I may claim, an international reputation.

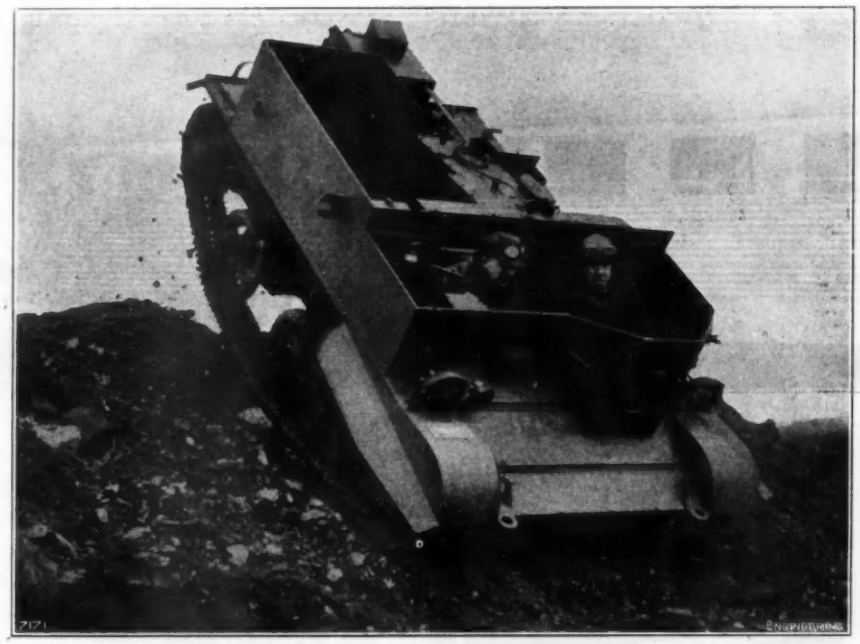
The Laboratories and Intelligence Sections of the Institute work in close co-operation in an endeavour to supply inquirers with the fullest and most useful information. After a sample has been examined in the laboratories, the results are often discussed with the Intelligence Staff, and from this collaboration it is frequently possible not only to give an inquirer a definite opinion regarding the quality or value of a product, but also to suggest means of improving its quality and the best means of finding an outlet for it. If a commercial valuation of a material is necessary, the Intelligence Staff from their knowledge of market requirements are able to suggest the most suitable commercial firms to whom samples should be submitted for opinion.

In conclusion, I venture to say a few words about our educational work at the Imperial Institute. Here we leave altogether the domain of the Special Library, but not altogether that of the Information Bureau. Perhaps the best description of this side of our work is that of a Visual Instruction Centre of the Empire, for here we combine all the latest technique in visual instruction. Our Exhibition Galleries, our Cinema and Empire Film Library, our Lantern-slides, Lectures, illustrated Postcards and School Specimens, all tend to secure the one object, namely, co-operation with school teachers in disseminating a more intimate knowledge of the geography, arts and industries of the Empire. The Exhibition Galleries are four in number—East, West, South and North—in all between one quarter and half a mile long. They are divided into Empire Courts, each country of the Overseas Empire being represented in its own Court; and they are so arranged that as you walk through the various Courts you follow the natural geographical sequence of the Dominions and Colonies.

So far as the development of natural resources is concerned, we are not content with merely showing specimens of ores or timber, oilseeds, gums or fibres. We try as far as possible to tell the whole story of the industry from the raw materials to the goods manufactured from them, thus linking geography with agriculture or forests or mines and again linking the Overseas Empire producer with the manufacturer whether he be a local manufacturer or of the United Kingdom. A Central Stand is maintained in a prominent position in the Galleries, where visitors on making verbal enquiries of the Officer-in-Charge are put in touch with the appropriate technical departments of the Institute or with the specialist officers dealing with them.

One of the most important developments in our information services at the Imperial Institute during the past few years has been the rapid advance in the use of the film as a means of supply of data concerning the life and industries of the Empire. The Imperial Institute Cinema and the Empire Film Library may be dealt with together. Our Cinema Hall was built for us in 1926 by the Empire Marketing Board; it has room to seat nearly 400 persons. Two years ago we installed sound projectors, and the experiment has been successful. The films are presented to us by authorities from all over the Empire, by Ministries and Departments of the United Kingdom Government, by local authorities, public utility and commercial and industrial companies, and by Governments, companies and individuals of the Overseas Empire. Our library of 1,500 Empire films has been built up from a nucleus of some 750 which we inherited from the Empire Marketing Board. These films are not only shown in our Cinema, but are also circulated on loan to schools and societies throughout the United Kingdom. Similarly, we circulate films of the G.P.O. Library, as agents for the Postmaster-General, and colonial films as agents for the Colonial Empire Marketing Board. During 1937 and again in 1938, we received grants from the Imperial Relations Trust for the purchase of new films for the Empire Film Library, and for the replacement of worn material. The total number of issues made during the first six months of 1938 from the G.P.O. and Empire Film Libraries was less than 15,000; during the same six

MACHINE-GUN CARRIER ON TEST.



months of 1939 the number of issues increased to over 22,000.

Our system of lectures can be briefly described. We have two Guide Lecturers on our staff. They have first-hand experience of the Overseas Empire, and are thus well qualified to explain the exhibits in our Galleries. Also, during the autumn and winter months, we are fortunate in securing, by co-operation with the Institute of Education, lecturers from the Dominions and Colonies who may happen to be in England on holiday or on study to come and give us lectures in our Cinema Hall, usually illustrated by lantern slides or films. The Victoria League bequeathed to us quite recently their well-known collection of some ten thousand lantern-slides for circulation in this country; and we are at present discussing with the Royal Empire Society the conditions on which they would be prepared to entrust us with the handling of their slides and their circulation to schools. With the co-operation of High Commissioners, of London agents for the Colonial Governments, and of other authorities we hope to build up this valuable nucleus of some 10,000 slides into a most useful and informative collection. Of private donors, I mention particularly Lord Bledisloe, who has given us much help from his truly remarkable collection of New Zealand and Rhodesian photographs.

MANUFACTURE OF ARMOURED TRACK-VEHICLES FOR WAR SERVICE.

In our issue for December 22 last, page 696, we gave a description of the methods of manufacture adopted in a factory producing trucks and lorries under war-time conditions. It may be of interest to compare these methods with those employed in a factory producing tanks and machine-gun carriers. It should be stated that, as mentioned in our article, the former factory had normally been employed in peace time on commercial-vehicle work, while the tank factory, except for part of the machine shop, was entirely new. It was, in fact, erected for the specific purpose of producing armoured fighting vehicles of the track type, and the organisers therefore enjoyed a certain advantage as regards freedom in selecting the most desirable layout as compared with those responsible for the conversion of the commercial-vehicle factory.

Building operations were started in June, 1937, and production was in full swing by February, 1938. The first delivery of machine-gun carriers was made at the end of May, 1938. Delivery has since continued uninterruptedly and at a progressively increasing production rate. The factory is of considerable extent, about 60 per cent. being allocated to the assembly and stores bays, and 30 per cent. for the machine shop. At the present time, the energies of the company concerned are directed towards the production of "cruiser" tanks in increasing numbers. These types of tank now going through the shop were developed by this company in conjunction with the Mechanisation Board, which is now part of the Ministry of Supply. In preparing this design, ease of production was considered of paramount importance. It was, therefore, planned for the building of the machine to be split up into assemblies of reasonable dimensions and to reduce as far as possible the number of different parts. This type of tank is also being manufactured by other tank constructors for whom the company is producing the engine, gearbox and other transmission details. Both these experimental tanks were made in a small neighbouring shop. These pilot tanks were subjected to very extensive and arduous testing by the Experimental Establishment at Farnborough, and not until they had completed many thousands of miles was the design approved and released for production. Since the beginning of this year, the company has delivered a number of these tanks, and a further large batch is now going through the works. As implied by its name "cruiser," this tank has a very high turn of speed owing to its high power-weight ratio and flexible independent suspension of the large bogie wheels. The machine gives very comfortable riding for the crew, and what is also important, a very steady gun platform. Entailed in the production of the modern tank are 6,200 detail parts requiring some 50,000 different machining and assembling operations. In addition to producing tanks and machine-gun carriers, the company has been responsible for the conversion of a large number of heavy howitzers from the old-type steel-tread tractor wheels to pneumatic tyres with hydraulic braking. This conversion enables a 9-ton gun to be towed at a safe speed four times higher than formerly. One of the machine-gun carriers produced is illustrated by the photograph reproduced on this page.

The machine shop houses some 300 machine tools of different types, but all of the most up-to-date pattern, thus giving the most economical and expeditious production. All the machine tools are provided with their own independent electric drive, thus doing away with overhead countershafts and belting. Every part produced in the factory, or bought out from sub-contractors, is inspected for accuracy of workmanship and finish to ensure that when it reaches the assembly bench it can be fitted together with its other mating part with the minimum of hand work. After leaving the firm's inspection department, every detail part is again inspected and approved by the Ministry of Supply inspectors, and is marked with a Ministry stamp so that no un-approved part can be used. Special gauges and very accurate measuring instruments are used for checking the parts passing through this department.

A brief description of the engine assembly may be of interest. Starting at one side of the assembly section, connecting rods are assembled with their bearings, etc. Every rod is checked for weight, the variation allowed being only ¼ oz. Adjacent are the balancing machines, on which all clutches, flywheels and engine fans are balanced to eliminate vibration when rotating at high speed. Following in sequence are the benches at which the air starter compressors, camshafts and their housings, cylinders, valve rockers, and inlet pipes are assembled. Water and oil pumps are built in a separate section, and here is installed a special machine for testing all oil pumps to determine the volume of oil pumped at varying speeds. At this part of the assembly section, the crankshaft with its connecting rods is fitted into the crankcase, the cylinders and timing gears and other units being added until the complete engine with flywheel and clutch leaves the section for the engine test. The engine-test section has been provided with a complete arrangement of petrol, water and oil supplies. The dirty oil discharged by the engine on test is passed through underground pipes to a dirty-oil tank, and is then purified by centrifugal cleaners, after which it is passed to an overhead clean-oil storage tank of 700 gallons capacity, and recirculated to the engine. Water used for cooling the engines and hydraulic brakes is circulated through a special cooler, thereby eliminating any wastage of water. The exhaust from the engines is passed into a large cast-iron pipe laid in a tunnel beneath the floor and discharged through a chimney passing out through the roof of the test shop. The exhaust discharge is assisted by a fan located at the outlet end of the pipe. After fitting the engine on the test stand, it is coupled up to its hydraulic brake and to the various oil, petrol and water services, and run under its own power at light loads, and at progressively increasing speeds for seven hours, after which it is run for three hours under full load. The test bed is so arranged that four engines can be tested at one time, and there is sufficient space to allow this number to be increased to seven. The gearbox-assembly section follows in line with the engine assembly, and here the various change-speed gears are fitted to their respective shafts and assembled into the gearbox. It should be noted that the gears used are of the straight spur type, the tooth form of which has been accurately produced by grinding.

The height of the vehicle-assembly shop provides sufficient head room to allow one tank to be lifted over those in course of production by a travelling crane. There are five bays, the first containing, at one end, the goods receiving space followed by the bar and steel stores, and again followed by the stores for all finished parts, the last section being allocated to heavy and bulky components. These stores feed the adjacent assembly bays with the necessary parts. The machine-gun carriers are constructed in the second bay; the operations of assembling following in sequence so that the finished vehicle is in position ready for loading direct on to railway trucks, which can be brought into the shop from the adjacent railway main line. The third bay is devoted to the building of "cruiser" tanks, which are laid down in parallel rows with assembly benches flanking the right-hand side of the bay at which the sub-assemblies are put together, and are in such a position as to coincide with the requirements of the tanks passing down the assembly line. These assemblies consist of such items as spring-suspension units, final drive, gears, axle arms, sprockets, change-speed control, steering levers, brakes and control, instrument panels and wiring, turntables and gunner's seat. The first operation here is the assembling of the right- and left-hand sides of the hull. This consists of steel plates to which various channels, angle irons and fittings are attached, by riveting. A heavy current is passed through the rivet, bringing it to a red heat in a few seconds. The floor of the tank constitutes a complete unit, and is assembled at this end of the shop. This moves forward and the two sides are then placed in position with the necessary division plates and bulkheads. The axle arms which carry the bogie wheels with the necessary springs and other components are fitted into place, after which the outer skin of armour plate is bolted into position. The fitting of these plates calls for a high degree of skill in order to ensure that the gap between the adjacent plates does not in any way exceed two-thousandths of an inch. This is necessary in order to afford the utmost protection for the tank crew. A special grinding machine has been installed to true up the edges of the armour plate to achieve this result. Meanwhile, the internal fittings are put into the plates, and by the time the vehicle reaches the end of this bay, it is complete with its wheels and is then passed into the fourth bay. In this bay the gearbox with the final drive and track driving sprockets, together with the engine, are fitted into position. Petrol tanks, radiators and the necessary pipe work are then installed. After filling up with petrol, oil and water, the engine is run up and the various gearbox gears are engaged to see that the installation is correct in all respects, after which the tracks and gun turret are fitted, and the vehicle then passes to the testing ground for a run of six miles, after which it is made ready for the final inspection test under Ministry of Supply supervision.

At the top end of this bay are assembled the gun mountings. These mountings are built up from components received from other sub-contractors. The work here entails the fitting of the telescope sight, firing gear and machine-gun brackets, and the aligning

STAINLESS-STEEL PASSENGER COACH; ITALIAN STATE RAILWAYS.

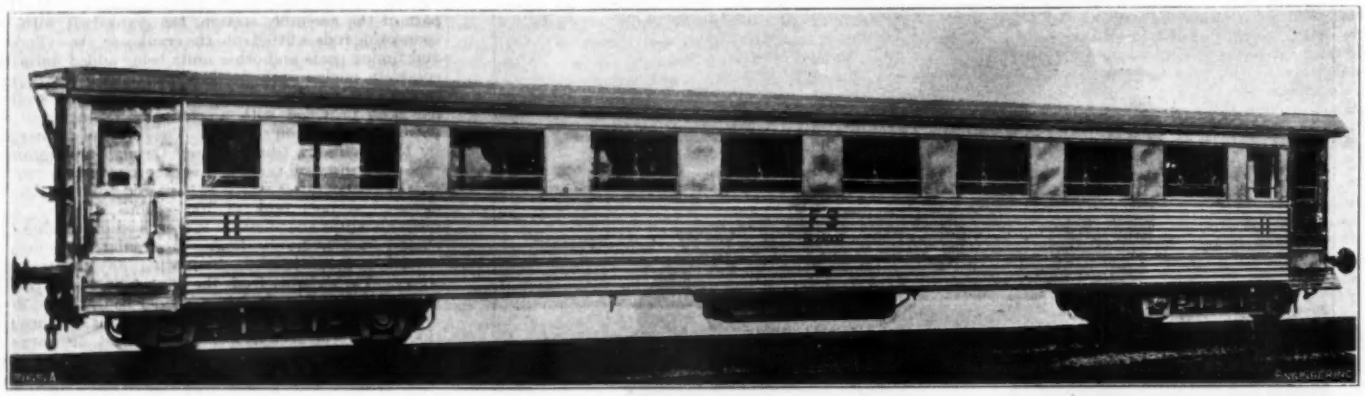


FIG. 1. GENERAL VIEW OF COACH.

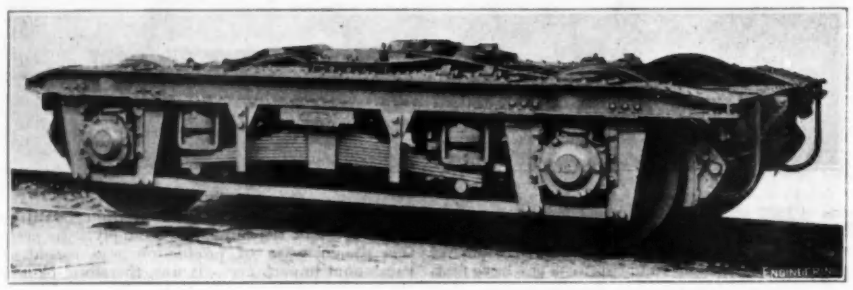


FIG. 2. FOUR-WHEELED BOGIE.

these parts together with the gun on to a target. The complete mountings are supplied to other tank constructors, as well as for fitting to turrets of tanks made at these works. The gun turrets are constructed as separate units in the last bay. These turrets are constructed entirely of bullet-proof plate, and the joint between the separating plates is made by internal angle irons fastened by riveting. The first operation in making these turrets is to assemble the side plates on a special jig so as to ensure their correct interrelationship and accurate fitting with the turret base ring. On the outside of the turret are fitted bullet-proof plates so as to provide additional protection, and these plates are all placed at an acute angle with the object of deflecting any bullets. On the inside of the rear of the turret is housed the wireless set with an external aerial mounting, and on the left-hand side is the rotating cupola provided with protected look-outs for the commander of the tank. On the front of the turret is fitted the gun mounting, which has been assembled in the preceding bay. The turret is mounted on rollers so that it can be completely rotated, and this rotation is effected by means of a hand gear engaging with a rack attached to the hull of the tank. In view of the large amount of detail parts in the construction of the turret, this entails a considerable amount of highly-skilled work. On completion, these turrets are lowered and attached to the tank proper and are tested for correctness before and after the tank has undergone its road test.

The completed machine is loaded with weights to correspond with that of the ammunition, wireless receiving and transmitting set, guns, etc., so that when tested the machine is of the same weight as in fighting trim. The machine is then driven to the testing ground situated approximately 12 miles from the works, and the speed over a quarter measured mile is taken *en route*. Owing to present conditions, these tanks are submitted to a somewhat abridged test, but records are taken of petrol consumption, oil and water temperature, and speed across country. The time taken for road and cross-country test is approximately 2 hours.

THE AMERICAN MOTOR-CAR INDUSTRY.—During November, 351,782 motor cars were produced by automobile manufacturers in the United States, against 313,377 in October, and 372,413 in November, 1938. The production in October was seriously hampered by a strike which affected several of the leading firms.

LICENCES FOR IRON AND STEEL PURCHASES.—From January 1, a new Direction (No. 2) issued by the Minister of Supply has superseded the Direction (No. 1) which was attached to the Control of Iron and Steel (No. 4) Order, 1939. The exemption of pre-war contracts from licensing requirements is removed, and save for Government Departments, and their contractors or sub-contractors, existing licensing exemptions are restricted to materials for use in the United Kingdom. Home iron ore, pyrites ash, burnt-pyrites residues, and boot and shoe grindery are added to the list of materials which may be acquired without a licence for use in the United Kingdom. Certain amendments in the provisions covering the purchase of small quantities without a licence restrict such purchases to a calendar week and specify use in the United Kingdom. Forms of application for licences may be obtained from the Iron and Steel Control, Steel House, Tothill Street, Westminster, S.W.1, where purchasers may also obtain advice and information.

RECENT DEVELOPMENTS ON THE ITALIAN STATE RAILWAYS.

THE programme for the extension of electrification on the Italian State Railways, which has been in hand for a number of years, was taken several stages nearer to completion in 1939. In particular, mention may be made of the inauguration of electric traction, on October 28, on the line running through Chiasso, Milan and Voghera, which will enable trains from the Swiss frontier, via the St. Gothard tunnel, to proceed directly to the south of Italy; and of the Falconara-Orte line, which provides a subsidiary electrified connection between the north and south of the country. The completion of these two sections increased the total length of the Italian electrified system from 4,823 km. (3,000 miles) at June 30, 1939, to 5,131 km. (3,188 miles) on October 28. Both of the new lines are supplied with direct-current at 3,000 volts through substations equipped with mercury-vapour arc rectifiers. One of these substations is situated at Milan, where the electrification of the railway station has involved a considerable amount of work. Monza station has been altered for electrified working, and Voghera station, where the direct-current system connects with the alternating-current system, has been replanned. The work on the Falconara-Orte line has required the reconstruction of several tunnels and the regrading of portions of the track.

The electrification programme of the Railways Administration provides for the conversion of a further 2,400 km. (1,491 miles) of track by the end of 1942, and it is expected that this will enable a reduction of 2,500,000 tons in the annual imports of coal, or about 20 per cent. of the present total: this is in addition to the reduction of 1,700,000 tons effected during 1938 and 1939. During the same two years, the operation of the electrified lines used about 1,000 million kWh of current, of which some 890 million kWh were supplied by privately-owned plants. To cover future power requirements, the Administration have made arrangements to increase the available supply of current to 1,500 million kWh. The speed of main-line traffic has been appreciably increased as a consequence of electrification. Between Rome and Naples, a speed of 123 km. (76 miles) per hour is now attained, and between Rome and Bologna, 125 km. (78 miles) per hour, as against the previous maximum of 117 km. (73 miles) per hour. The journey time between Milan and Naples has now been reduced to 7 hr. 26 min., including 11 minutes lost in stops at Bologna, Florence and Rome. Express freight services also have been introduced, running, for example, at 90 km. (56 miles) per hour on the line from Reggio to Rome. Where previously the through trains carrying vegetables and fruit from Sicily to the Brenner district took 105 hours, the journey is now made in less than 50 hours.

Among the constructional works undertaken on the State Railway system have been the building of the new Central and Maritime station at Messina and the re-organisation of the various stations in Rome, the latter works including the construction of a goods line from Roma Tiburtina to Settebagni and of the Roma Littorio marshalling yard. Passenger stations have been rebuilt at Turin, Alessandria, Udine, Carrara, Siena, Bari, Reggio Calabria, and about a dozen other towns. The new terminus at Venice is still under construction, as well as the enlargement of the stations at Trieste and Genoa. On several lines the signalling system has been entirely renewed, and the track between Narni and Terni has been doubled. During 1938 and 1939, the builders of rolling stock have delivered 137 electric locomotives, 47 electric railcars, 4 streamlined trains, 20 train sets, and 50 Diesel-engined railcars; and, in addition, they have fitted continuous brakes to 12,000 freight cars.

On the line between Milan and Bologna, experiments are being carried out with railcars driven by gas engines using methane; and between Genoa and Milan, similar tests are being made with railcars fitted with a type of gas engine, supplied by producers using charcoal, which has been developed by the Società Anonima Ansaldo. If these trials are satisfactory, it is intended that engines of this type shall be used to replace the Diesel-engined railcars, in order to reduce the consumption of oil, which must be imported. In addition to these new departures in railway practice, the works of Messrs. Piaggio, at Genoa Sestri, are engaged on the construction of stainless-steel passenger coaches and of two train sets, also in stainless steel, under licence from Messrs. Budd and Company, of Philadelphia.

The stainless-steel coaches are to be used on the main lines, both in complete trains and also in conjunction with other stock, the coupling and braking arrangements being identical with those of the existing coaches used in the main-line trains. The main dimensions of the new stock, illustrations of which appear in Figs. 1 to 4, on this and the opposite pages, are: length over buffers, 21·825 m. (71 ft. 7 in.); extreme breadth, 2·957 m. (9 ft. 8½ in.); height above rail level, 3·71 m. (12 ft. 2 in.); height from rail level to coach floor level, 1·247 m. (4 ft. 1 in.); length between bogie centres, 15·485 m. (50 ft. 9½ in.); and centres of bogie wheels, 2·7 m. (8 ft. 10 in.). The wheels are 0·9 m. (2 ft. 11½ in.) in diameter. The weight of each car,

STAINLESS-STEEL PASSENGER COACH.

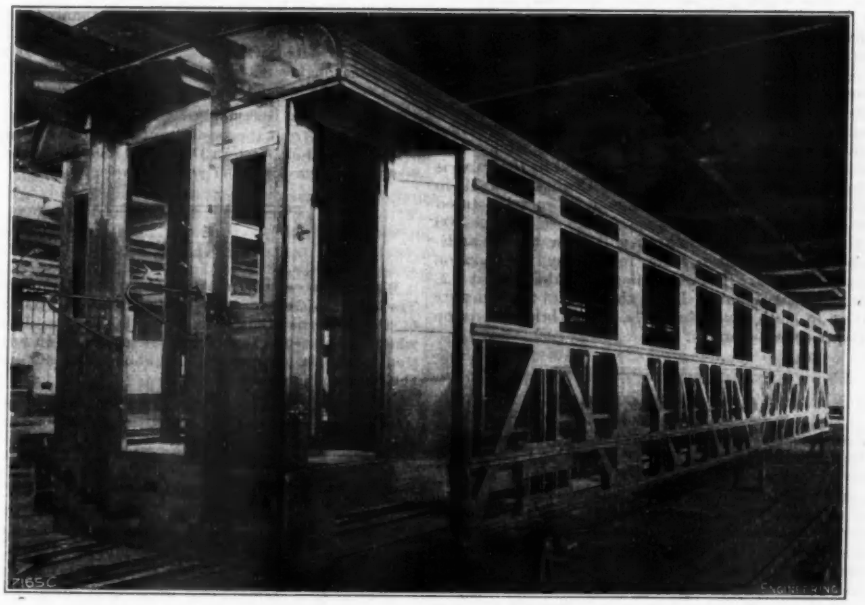


FIG. 3. FRAMEWORK OF COACH BODY.

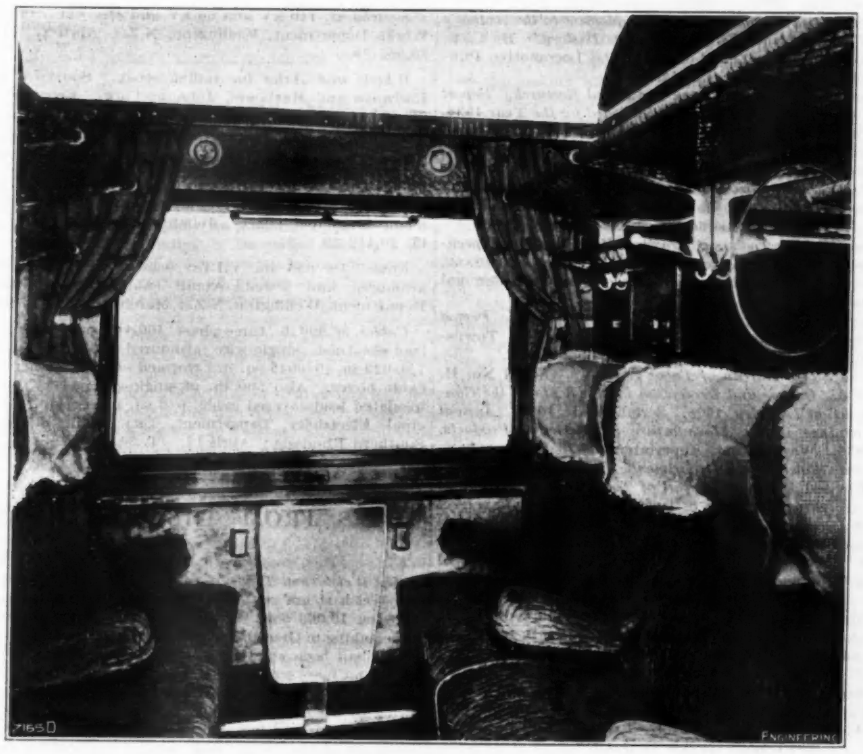


FIG. 4. INTERIOR OF FIRST-CLASS COMPARTMENT.

ready for service, is 18 tons, as against the 44 tons of existing coaches, of similar dimensions, in use on the Italian State Railways. Particular importance is attached to this reduction of weight, as it is estimated that the smaller weight of the new coaches will result in a saving of 18,000 lire per annum in the cost of haulage, apart from the anticipated reduction in maintenance costs and the smaller quantity of metal required for the construction of the stock.

As can be seen from the illustrations, the coaches are of the end-vestibule type, with four-wheeled bogies, and have two doors at each end. The equipment includes automatic brakes on the Breda system, operated by compressed air and designed for braking at high train speeds; an alarm signal which also applies the brakes; and a hand brake, acting on all the wheels, operated from one of the vestibules. A Westinghouse steam-heating plant is fitted, and accumulators for lighting purposes. The bogies, one of which is shown in Fig. 2, are of riveted construction, in mild steel, and weigh 5,500 kg. (5 tons 8 cwt.) each. The suspensions consists of leaf springs. The axle bearings are of the R.I.V. type, and support the bogie frame through a system of double springs. The framework of the coach body, the construction of which is illustrated in Fig. 3, is of stainless steel, welded throughout, and is covered with stainless-steel sheets, designed to be readily removable. The main longitudinal and transverse members are also of stainless steel. The walls, ceiling and floor are covered with insulating and anti-vibration material. The interior furnishings are constructed in mahogany, with non-corrodible metal fittings, and the window frames are of stainless steel. Ventilating sashes are provided, and are fitted with balancing devices to hold them in position. The flooring consists of corrugated stainless-steel sheets, fitted with Litosilo, over which are laid felt, linoleum and a woollen carpet. A lavatory compartment is situated at each end of the coach. The compressed-air brake cylinder is carried under the framing in the usual manner and actuates the two brake blocks on each wheel through rigging of the type now standard on the State Railways' coaching stock.

THE OPERATION OF MAGNETIC-DRUM SEPARATORS.

IN the issue of ENGINEERING for November 26, 1937, vol. 144, page 606, an account was given of a "Biaflux" electromagnetic drum, 36 in. in diameter by 6 ft. long, installed at the head of a sugar-cane carrier in a large South African mill. The separator was supplied by Messrs. The Rapid Magnetting Machine Company, Limited, Magnet Works, Lombard-street, Birmingham, 12, and we are now able to supplement the account by some particulars of its operation, these particulars having been supplied to the makers by the users of the machine. It will, no doubt, be somewhat surprising to most engineers to learn that the amount of tramp iron present in the material dealt with in the mill is large enough to cause considerable damage to the crushing rollers, yet such is the case, as the cost of repairing this damage, when the 1937 crop was being handled, was estimated to lie between 500*l.* and 550*l.* This cost was incurred before the separator had been installed, and, in addition, a total of 13 hours 20 minutes was lost in removing the iron from the shredder. The separator was working for the 1938 crop, a period of six months, and during this time 575 lb. of tramp iron was intercepted. The iron pieces varied in size and weight from an ordinary safety pin to pieces as heavy as 16 lb. each. This was not the whole of the iron present, but the time lost in removing the remainder was only 5 hours 48 minutes, that is, it had been reduced to considerably less than half of what it had been in the previous year. The damage done to the rollers in 1938 was so slight as to be negligible, so that the outlay for repairs was eliminated.

It might be argued from the above that, definite as was the improvement effected by the employment of the separator, the machine was not fully efficient or the whole of the iron would have been caught. This was, however, due to the fact that the layout of the plant, already in existence, did not permit the separator to be placed in the most effective position. In this connection it may be pointed out that no hard and fast rule as to the best position for a magnetic separator can be laid down, as this varies with the material being handled, *e.g.*, on its density, rate of flow, magnetic permeability of intrusive contents, etc. Each case must, therefore, be considered relatively to the material, for example, though the case referred to above is a specific one, the same type of magnetic drum can be employed with satisfactory results on other material than sugar cane. In the sugar industry it is used to remove the fine iron scale that unavoidably finds its way into granulated sugar, while it is employed also in the treatment of foundry sands and for the separation of the tramp iron which is almost invariably present in the materials produced in mining and quarrying work.

A very recent development of the magnetic-drum separator may here be fittingly commented on, viz., the application of a forced-ventilation system to it. It will be remembered, from our previous accounts of these appliances, that the magnetic-drum separator consists of a thin drum revolving round a fixed electromagnet system occupying the front half, diametrically, of the drum. The material to be treated is fed on to the bare drum from the surface off which it is subsequently flung by centrifugal force, the iron adhering to the drum until it is carried out of the magnetic field, when it is thrown off down a separate chute to that for the cleansed material. Although the drum is a fairly close fit to the electromagnetic system, there is, of necessity, a clearance space between the two, and the air-gap thus formed not only takes up uselessly a valuable part of the magnetic field, but prevents heat being dissipated from the magnet windings, the motion of the drum not having any appreciable air-circulating effect. The new ventilating system consists of the provision of a motor-driven centrifugal air-blowing unit with detachable air filters, and this unit enables the temperature of the windings to be kept at a safe figure while carrying a much heavier electrical load than is possible with an unventilated drum. Naturally, this increased wattage, which is about 300 per cent., is accompanied by a considerable increase in the magnetic strength of the drum, a valuable feature as it enables a smaller drum to be used than would normally be necessary, or, with the same size drum, a greater separating efficiency to be obtained, a point of great importance where feebly-magnetic material is concerned.

The last sentence does not imply that the employment of the forced-ventilation system involves absolute standardisation of design, since different materials

require different magnetic flux density, the securing of which depends on the design of the particular drum. Thus, when a magnetic drum extractor is used to separate tramp iron from material fed on to the drum in a thick layer, a penetrating magnetic field is required while, when feebly-magnetic particles are being removed, a field of a more intense nature is necessary. Apart from the increased magnetic efficiency obtained by the adoption of the forced ventilation system, it has proved of great value in treating hot materials, having been employed, for instance, in dealing with red-hot slag in a slag works. In the tropics, also, the system is of considerable benefit, in cases of exceptional heat and where adequate cooling water is available, a closed air circulating system being provided. In all cases, the air ducts are designed so that the air from the blower is expanded after compression, with the result that its temperature is slightly lower than that of the atmosphere. The system keeps the temperature of the windings within the limits permitted by present-day regulations when the separator is run continuously. Cases of this nature occur, for example, in sugar works, where drums of 30 in. and 36 in. in diameter usually run for 24 hours per day, six days per week, the material to be extracted being, moreover, only feebly-magnetic and thus calling for an intense field. The forced ventilation system has solved the problems which formerly existed in installations of this type.

ANNUALS AND REFERENCE BOOKS.

Diaries and Pocket Books.—Messrs. The Staveley Coal and Iron Company, Limited, near Chesterfield, have sent us an attractive leather-bound pocket diary containing brief particulars of their sand spun, metal spun and cast-iron pipes and other products, and miscellaneous data of interest to engineers.—A useful pocket diary, bound in leather, has been sent to us by Messrs. The Stanton Ironworks Company, Limited, Stanton-By-Dale, near Nottingham. Included are 76 pages of information concerning the firm's spun iron, cast-iron and concrete pipes and specials, and other products.—Messrs. B.S.A. Cycles, Limited, Birmingham, 11, have sent us a diary issued by Messrs. Wm. Jessop and Sons, Limited, Brightside Works, Sheffield. This contains succinct particulars of Messrs. Jessop's carbon, magnet, stainless and other special alloy steels, steel castings, files, cemented-carbide cutting alloy and other products, and conversion tables and other miscellaneous information.

The Coal Trades' Diary and Colliery Managers' Guide for 1940.—In addition to being a desk diary of foolscap size, having three days to each page, this volume contains 210 pages of information of interest to mine officials. The first 120 odd pages are devoted to reproductions of the Coal Mines Acts of 1911, 1914, 1919, 1926, 1930, 1931, 1932, 1937 and 1938, of other legislation concerning quarries, metalliferous mines and collieries, and of the Employers' Liability and Workmen's Compensation Acts. An abstract of the Factories Act, 1937, is also included. The remainder of the information section consists mainly of a coal-trades directory. The coalfields of England, Scotland, Wales and Ireland are listed by districts and the colliery companies in each district are given in alphabetical order. The particulars furnished for each company include the postal address, the names and situations of individual pits, the class of coal mined, the number of workpeople employed, and the names of the certificated managers, agents and engineers of the colliery. The directory section of the volume closes with lists of official committees concerned with the mining and quarrying industries, of Government Mines Inspectors, and of officials of the Mining Association of Great Britain, the National Association of Colliery Managers, the various associations and federations of mineworkers, the Institution of Mining Engineers, and other associations and bodies connected with collieries and mining. The Diary and Guide is published, price 6*s.* 6*d.*, by Messrs. F. W. Bridges, Limited, 9, Fryston-avenue, Croydon, Surrey.

Whitaker's Almanack, 1940.—Among the indispensable reference books, *Whitaker's Almanack* occupies an important place. The amount of information it contains is so extensive and covers such a multitude of detail, that one has developed the habit of referring to it for assistance on almost any subject. It is probably for statistics, or specific facts, such as the office address of a public body, that the volume is mainly consulted, but its contents are far from merely tabular and, for instance, a brief but clear account of the constitution of the Department of Scientific and Industrial Research will be found in its columns. No annual can serve the same purpose as a daily newspaper, but the 1940 edition of Whitaker—the 72nd annual volume—brings its account of current affairs very close to the day of publication. The sketch of "The War Against Aggression," as it is well termed in the volume, carries matters down to the decision to impose bacon and butter rationing in Great Britain. New tables which have been added this year, and which are of particular value under present conditions, concern the productive capacity of the allied and neutral nations and food imports from British and foreign sources. Whitaker has a high reputation for accuracy, and it would be a cheerless occupation to search its pages for mistakes or omissions. Partly by chance, we have noticed, however, that in the section dealing with bridges over the Thames, while it is stated that Waterloo Bridge was opened in 1817 and is now being rebuilt by the London County Council, in the case of Wandsworth Bridge it is merely stated that it was opened in 1873. A reference to page 000 of this issue of ENGINEERING will show that Wandsworth Bridge is also being rebuilt by the London County Council. The Almanack is published at 12, Warwick-lane, London, E.C.4, the price of the complete edition in cloth covers being 7*s.* The abridged edition in paper covers costs 3*s.* 6*d.*

BOOKS RECEIVED.

An Almanack for the Year of Our Lord 1940. By JOSEPH WHITAKER. London: J. Whitaker and Sons, Ltd. [Price 7*s.* net.]

Canada. Department of Mines and Resources. Bureau of Mines. The Mining Laws of Canada. A Digest of Dominion and Provincial Laws Affecting Mining. Compiled by ARTHUR BUISSON. Revised edition. Ottawa: Bureau of Mines. Department of Mines and Resources. [Price 25 cents.]

Ministry of Health. Local Government Financial Statistics. England and Wales. 1936-37. Part II. *Local Authorities in London and County Boroughs.* London: H.M. Stationery Office. [Price 3*s.* 6*d.* net.]

Early British Locomotives. A Supplement to the Author's 'Two Essays in Early Locomotive History.' By C. F. DENDY MARSHALL. London: The Locomotive Publishing Co., Ltd. [Price 12*s.* 6*d.*]

Department of Scientific and Industrial Research. Report of the Forest Products Research Board for the Year 1938. London: H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

Micrometers, Slide Gauges and Calipers. Principles, Construction, Operation and Use of Appliances for Fine Mechanical Measurements. By A. W. MARSHALL and GEORGE GENTRY. London: Percival Marshall and Co., Ltd. [Price 1*s.* 6*d.* net.]

Metal Working Tools. A Practical Handbook for Apprentices and Amateur Mechanics. By PERCIVAL MARSHALL. Revised and enlarged edition. London: Percival Marshall and Co., Ltd. [Price 1*s.* 6*d.* net.]

Report of the Townsville Harbour Board for the Period from 1st January, 1936, to 31st December, 1938. Townsville, Australia: Offices of the Harbour Board.

United States Bureau of Labor Statistics. Serial No. R. 1003. *Causes and Prevention of Accidents in the Construction Industry,* 1938. Serial No. R. 1015. *Annual Earnings in the Manufacture of Electrical Products,* 1936. Washington: Superintendent of Documents.

United States War Department. Lake Series No. 7. (Revised 1939.) *The Port of Toledo, Ohio.* Washington: Superintendent of Documents. [Price 75 cents.]

United National Bureau of Commerce. Building Materials and Structures. Report BMS 27. *Structural Properties of "Bender Steel Home" Wall Construction Sponsored by the Bender Body Company.* By H. L. WHITTEMORE, A. H. STANG and V. B. PHELAN. Washington: Superintendent of Documents. [Price 10 cents.]

United States Bureau of Mines. Mica. By P. M. TYLER and K. G. WARNER. Washington: Superintendent of Documents. [Price 5 cents.]

Mines Department. Safety in Mines Research Board. Paper No. 103. *Back-Stays for Use in Mines.* By W. A. JOHNSON and P. G. TAIGEL. London: H.M. Stationery Office. [Price 1*s.* net.]

THE IDENTIFICATION OF AIRCRAFT.—With the object of assisting members of the Services, the Observer Corps, Police, and A.R.P. workers, in what is admittedly an exacting task, Messrs. Temple Press, Limited, Bowling Green-lane, London, E.C.1, the publishers of *The Aeroplane*, have issued a handy pocket-size booklet entitled *Aircraft Identification*. This gives clear three-position silhouettes of all the leading types of British and enemy aircraft, including seaplanes and flying boats. Each type is also represented by a reproduction of a close-view photograph and the book contains, in addition, a double-page illustration of belligerent types shown head-on against a natural background of clouds. A few views of the leading machines employed by our French allies are included. A second edition of the work, which includes an illustrated description of the last British bomber, the Bristol-Beaufort, and silhouettes of the new German Ju88K, are included. The price is 1*s.* 3*d.* net.

PERSONAL.

WE are informed that MR. HARRY PHILIP GAZE, M.Inst.C.E., M.I.E.E., chief generation engineer to Messrs. The London Power Company, Limited, retired on December 30, 1939, on reaching the age limit, and is now associated with Messrs. Kennedy and Donkin, consulting engineers, 12, Caxton-street, London, S.W.1, in an advisory capacity on power-station work.

MR. WALTER PATERSON, M.I.Loco.E., retired on December 31 from the position of assistant superintendent of operation, Western Division, London Midland and Scottish Railway, after 47 years' service.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Steel Bars, flat, square, channel and angle. South African Railways and Harbours, Johannesburg; February 12. (T. 30,206/39.)

Locomotive Boilers, three, fitted with steel fireboxes. South African Railways and Harbours, Johannesburg; February 5. (T. 30,410/39.)

Passenger Lift, air electric for the General Post Office at Pretoria. Union Tender and Supplies Board, Pretoria; February 1. (T. 30,414/39.)

Electric Book Lift, having a car approximately 3 ft. wide by 2 ft. deep by 3 ft. high, for the South African Library, Cape Town. Union Tender and Supplies Board, Pretoria; January 25. (T. 30,415/39.)

Switchgear, 110 kV and 66 kV and steelwork. Public Works Department, Wellington, N.Z.; April 2. (T.Y. 30,385/39.)

Wheels and Axles for rolling stock. South African Railways and Harbours, Johannesburg; February 19 (T. 30,398/39.)

Steel Boiler Tubes and superheater flue tubes. South African Railways and Harbours, Johannesburg; February 12. (T. 30,411/39.)

Oil Purifiers. City of Johannesburg Stores Department, Municipal Offices, Johannesburg; February 10. (T. 30,412/39.)

Cable, 3/0·036 in. V.I.R., lead-covered, single-wire armoured and sewed overall cable. Public Works Department, Wellington, N.Z.; March 5. (T. 30,431/39.)

Cables, 36,000 lb., three-phase, 400-volt paper-insulated lead-sheathed, single-wire armoured cable, each core 7/0·029 in. (0·0045 sq. in.) wormed cores, together with cable boxes. Also 500 lb. of single-core, 11-kV paper-insulated lead-covered cable, 0·6 sq. in. section. Municipal Electricity Department, City Hall, Salisbury, Southern Rhodesia; April 15. (T. 30,438/39.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—An inquiry was circulating on the Welsh steam coal market during the past week for between 10,000 tons to 15,000 tons from an electricity undertaking in Greece, while the Greek Thessaly Railway, which had been showing interest, was reported to have placed business with local shippers. At one time, Greece was a large customer for Welsh coals, but of late years, owing to her export subsidy, Germany has succeeded in securing an increasing share of the business. With the outbreak of the war, Greek buyers displayed a better interest on the local market than had been the case for a long time. A good demand was again circulating on the market from both home and overseas customers. The amount of new business, however, that could be accepted remained limited, owing to the difficulties that confronted operators. Collieries' present outputs were largely accounted for by the deliveries made on account of past commitments and offers of the more favoured kinds were again restricted to occasional small parcels. As stems were well filled for some months to come, the general tone continued very firm. Duffs were particularly difficult to stem, while sized sorts and all the large descriptions were well booked with orders. Smalls, with the exception of the inferior kinds, were not very plentiful. Cokes and patent fuel, however, were active.

The Iron and Steel Trade.—Busy conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. There was a good demand circulating and order books were well filled ahead, the outlook appearing very favourable. Most works are engaged almost to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—After the holiday shut-down the production of steel, machinery, and engineering products generally is again in full swing, plants that had worked at high pressure since the beginning of the war having been overhauled. Mr. W. Dodgson, divisional officer for the Sheffield and Lincolnshire districts of the Iron and Steel Trades Confederation, reports that conditions show little change. The whole of the steel productive plants are working to capacity, while the malleable-iron trade is very active. There is a strong demand for all types of machinery. Extensions to steel and engineering works have benefited makers of rolling mills, forging plant, presses, grinders of all types, and lathes. The call for railway rolling stock shows further expansion; not only are inland needs on the increase, but more orders are coming to hand from abroad. The recent run on shipbuilding steel and auxiliary equipment has been maintained, and a further increase is reported in motor-car accessories. Active conditions prevail in the production of electrical goods, whether in the form of parts for transformers and switchgear, or electric traction motors. The season in farm and garden machines and tools has opened on promising lines. There is a steady influx of orders on inland account, while overseas requirements are considered to be satisfactory. Toolmakers are exceptionally busy and outputs of machine tools are reaching record dimensions. Extensions are taking place to works producing bolts and nuts, and file makers are better employed.

South Yorkshire Coal Trade.—The inland demand for industrial fuel has been maintained. Iron and steel works are taking increased tonnages of steam coal. Smalls are moving more freely to electricity-generating stations, and there has been an increased demand for house coal. Most types of coke are in demand on inland account. The export position shows little change; supplies to the Scandinavian countries have been maintained.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The Scottish steel trade has resumed its exceptional activity as the necessary repairs and overhauls of plant during the holiday stoppage were pushed forward as rapidly as possible. The output for the twelve months ending in December reached a very high tonnage, but no production figures can be given at the moment. At present all makers have very heavy order books and are being constantly subjected to steady pressure from consumers for supplies. Everything possible is being done to speed up deliveries. Despite home requirements, a fair tonnage of steel is being shipped overseas under licence from the Government. Shipbuilders are practically full up with orders and it is a long time since the demand from the industry for plates, etc., was as heavy as it is at the present time. Steelmakers are also experiencing a very strong demand from the re-rollers for semies. The makers of black steel sheets have many important contracts to complete and can look forward to full employment for months to come. The following are the current prices:—Boiler plates, 12*l.* 8*s.* per ton; ship plates, 11*l.* 10*s.* 6*d.* per ton; sections, 11*l.* 8*s.* per ton; medium plates, 13*l.* 2*s.* 6*d.* per ton; black steel sheets, No. 24 gauge, 16*l.* 2*s.* 6*d.* per ton; and galvanised corrugated sheets, No. 24 gauge, 18*l.* 12*s.* 6*d.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—In the malleable-iron trade of the West of Scotland a fair amount of new business has recently been booked and the majority of the works are very well employed. There has been a slight scarcity of malleable-iron scrap lately, but the outlook is now much better. The re-rollers of steel bars have had a strenuous time for many months, and the orders now on hand indicate that this is likely to continue. The delivery of semies from the local steelworks is good, while the imports from the Continent are more satisfactory. The current quotations are as follows:—Crown bars, 12*l.* 15*s.* per ton; re-rolled steel bars, 12*l.* 19*s.* per ton; No. 3 bars, 12*l.* 7*s.* 6*d.* per ton, and No. 4 bars, 12*l.* 12*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There has been no falling-off in the demand for Scottish pig-iron since the year-end holidays, and the pressure for deliveries of both hematite and basic iron is stronger than ever. The requirements of industry are exceedingly large and in order to meet the demand an increase is being made in production. Foundry iron is moving more freely, but the demand from the light-castings industry is still rather dull. The following are the current market quotations:—Hematite, 6*l.* 4*s.* 6*d.* per ton, and basic iron, 5*l.* 1*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 12*s.* per ton, and No. 3, 5*l.* 9*s.* 6*d.* per ton, both on trucks at makers' yards.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Strict control of distribution of iron and steel is still necessary to ensure that Government needs are adequately dealt with. There is continued pressure for supplies for national requirements, but producers of one or two commodities are gradually providing rather more tonnage for general industrial purposes, the demand for which is considerable.

Cleveland Iron Trade.—Suspension of Cleveland-pig production is causing no uneasiness and a movement towards the resumption of the regular output is not yet in sight. North of England foundry-iron consumers are receiving adequate supplies from elsewhere. Deliveries of Midland brands are large and increasing. Occasional parcels of Continental iron continue to be offered here, but the prices named are much above quotations for home products and attract little attention. Merchants have practically no opportunity of handling Cleveland pig, the stocks of which have been almost cleared. Fixed prices of Cleveland pig remain on the basis of No. 3 description at 108*s.*, delivered within the Tees-side zone.

Hematite.—The large production of East Coast hematite being insufficient for current needs, makers are showing less inclination to discuss new business. Although the tonnage accumulations at the blast-furnaces are heavy, a good deal of the iron stored is earmarked for use at the producers' own consuming departments, and delivery obligations to customers who are dependent on the market for supplies are considerable. Buyers are anxious to take up full deliveries under running contracts, and are desirous of buying ahead. The statistical situation, however, is satisfactory. The supply is confidently believed to be equal to requirements for a long time. Second hands still have a little hematite on hand, but experience difficulty in making purchases and are distributing their holdings cautiously. Stabilised quotations are at the equivalent of No. 1 grade of iron at 124*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—All the output of basic iron is absorbed by the makers' adjacent steelworks, and the quotation of 101*s.* 6*d.* is nominal.

Foreign Ore.—Consumers of foreign ore are fairly well placed as regards stocks, and imports are better than was expected and are increasing.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is quiet. Local users have made provision for their needs over a considerable period and sellers are not anxious to enter into new contracts. Prices are ruled by good medium qualities at 29*s.* 2*d.* at the ovens.

Manufactured Iron and Steel.—Expansion in the home production of semi-finished iron and steel and an increase in supplies from abroad enable re-rollers to keep their plant busily employed. Manufactured-iron firms are turning out increasing tonnage, and producers of finished steel are maintaining outputs at nearly the record level, with the result that a rather larger proportion of the make is allocated for overseas shipment. For home trade, soft-steel billets are quoted 8*l.* 7*s.* 6*d.*; hard-steel billets, 9*l.* 10*s.*; steel ship, bridge and tank plates, 11*l.* 10*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; joists and sections, 11*l.* 10*s.*; black sheets, No. 24 gauge, 16*l.* 2*s.* 6*d.*; and galvanised corrugated sheets, No. 24 gauge, 18*l.* 12*s.* 6*d.*

Scrap.—A sharp rise in imports of scrap has materially eased the position, which promises to be further improved by the arrival of more cargoes from overseas.

RETROSPECT: ERRATUM.—In our article entitled "Retrospect," on page 13 of last week's issue, and in the last paragraph on that page, it was stated that "The official channel for applications of this kind from Empire countries is through the local British Consul . . ." This statement, of course, should have been applied to "other than Empire countries."

PETROL FOR AGRICULTURAL MACHINERY.—It is announced in a circular issued to members of the London Chamber of Commerce, that as from January 1, 1940, the Secretary of Mines is introducing a system of petrol distribution to farmers by coupons. The previous temporary arrangements which permitted the purchase, without coupons, of motor spirit for agricultural purposes, were made to cover the exceptional requirements of harvest and autumn ploughing, and expired on December 31. The first period to which the new arrangements will apply cover the months of January and February, 1940. Farmers and ploughing contractors, who require motor spirit for agricultural tractors, stationary engines, or vans and lorries operating on an "F" licence, should apply to Divisional Petroleum Officers on Form R (M.S.) 6, which can be obtained from local taxation offices or post offices. Farmers' private motor cars, and lorries operating on carriers' licences, are not included in this scheme.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. Lecture: "The Application of the Photo-Electric Cell in Industry," by Mr. J. B. Kramer.

JUNIOR INSTITUTION OF ENGINEERS.—To-night, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "The Engineer and Salesmanship," by Mr. R. G. Williams. *Midland Section:* Saturday, January 20, 2.30 p.m., The James Watt Memorial Institute, Birmingham. "Recent Developments in the Use of Town's Gas and Other Gases for Traction Purposes," by Dr. C. M. Walter.

INSTITUTION OF PRODUCTION ENGINEERS.—*Edinburgh Section:* Saturday, January 13, 3 p.m., The North British Station Hotel, Edinburgh. Informal Discussion. *Birmingham Section:* Wednesday, January 17, 7 p.m., The James Watt Memorial Institute, Birmingham. "Production Planning with Special Reference to the Bedding Industry," by Mr. S. Waugh. *Leicester Section:* Thursday, January 18, 7.30 p.m., The College of Technology, Leicester. "Progress in Machine Tool Design" by Mr. R. C. Fenton.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Scottish Branch:* Saturday, January 13, 3.30 p.m., The Royal Technical College, George-street, Glasgow. "Cast Iron for Modern Engineering Applications," by Mr. T. Tyrie.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Western Centre:* Monday, January 15, 3 p.m., The South Wales Institute of Engineers, Cardiff. "Electrically Manufactured Steels," by Mr. H. A. Sieveking.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*London Graduates' Section:* Tuesday, January 16, 7 p.m., 12, Hobart-place, S.W.1. Discussion on "Fuel for Road Vehicles in the Year 2000," to be opened by Messrs. F. W. K. Judd, C. P. Carmichael and J. B. Perrett. *North-Western Centre:* Wednesday, January 17, 7.15 p.m., The Engineers' Club, Albert-square, Manchester. Discussion on "Accidents," to be opened by Mr. H. Strange.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, January 16, 6.30 p.m., The Lighting Service Bureau, 2, Savoy-hill, W.C.2. Lecture: "The Development of Sound Equipment," by Mr. D. T. Bennett.

ROYAL SOCIETY OF ARTS.—Wednesday, January 17, 2.30 p.m., 18, John-street, Adelphi, W.C.2. "Applications of X-Ray Technique to Industrial Problems," by Mr. H. P. Rooksby.

ROYAL INSTITUTION.—Wednesday, January 17, 5.15 p.m., 21, Albemarle-street, W.1. "Theory of Nuclear Forces," by Professor R. Peierls.

INSTITUTION OF MINING AND METALLURGY.—Thursday, January 18, 2.30 p.m., The Geological Society's Rooms, Burlington House, Piccadilly, W.1. (i) "The Correlation of Strata at Halkyn Mine, North Wales, by the Study of Involuble Residues," by Mr. K. Khosrovani. (ii) "Notes on the Maintenance of Inclination and Direction in Inclined Shafts," by Messrs. J. E. Metcalfe and A. R. Jones. (iii) "Notes on a Tubular Steel Head-Gear for a Small Mine Shaft," by Mr. A. A. Jones.

BRITISH INSTITUTE OF RADIOLOGY.—Friday, January 19, 2 p.m., 32, Welbeck-street, W.1. Twenty-Second Silvanus Thompson Memorial Lecture: "The Irradiation of Liquids," by Professor F. L. Hopwood.

THE INSTITUTE OF PETROLEUM.—A meeting of the Institute of Petroleum will be held at the Royal Society of Arts, John-street, London, W.C.2, at 2.40 p.m., on Friday, January 26, when Professor A. W. Nash will deliver his presidential address.

ROYAL NAVAL PATROL SERVICE.—The Admiralty asks us to announce that engine men with experience in trawlers and drifters are required immediately for the Royal Naval Patrol Service, for the duration of the war. They are requested to apply at once to the nearest registrar, Royal Naval Reserve, or Fishery Office.

MESSRS. VICKERS-ARMSTRONGS LIMITED.—In addition to the calendars, etc., sent to us, and which have been previously acknowledged, we have received from Messrs. Vickers-Armstrongs Limited, London, a wall calendar reproducing in colour a striking painting of H.M. destroyer Eskimo at full speed, executed by Mr. Montague Dawson. H.M.S. Eskimo, a destroyer of the new "Tribal" class, was completed at the Naval Yard of Messrs. Vickers-Armstrongs, Limited, High Walker, a year ago. She has a displacement of 1,870 tons and an overall length of 356 ft., and carries eight 4-in. guns, mounted in pairs.

VARGÖN POWER STATION OF THE ROYAL SWEDISH WATERFALLS BOARD.

(*For Description see Page 27.*)

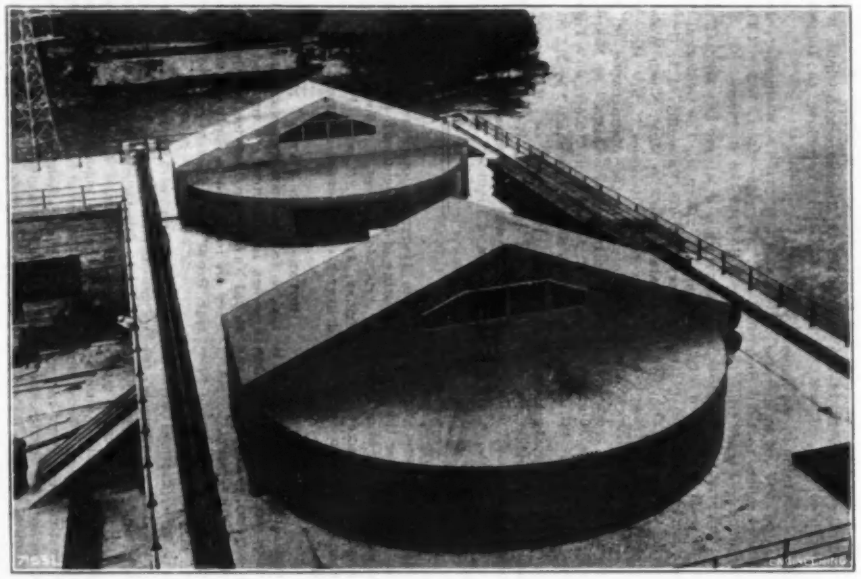


FIG. 12. GENERATOR HOUSINGS ON ROOF OF STATION.

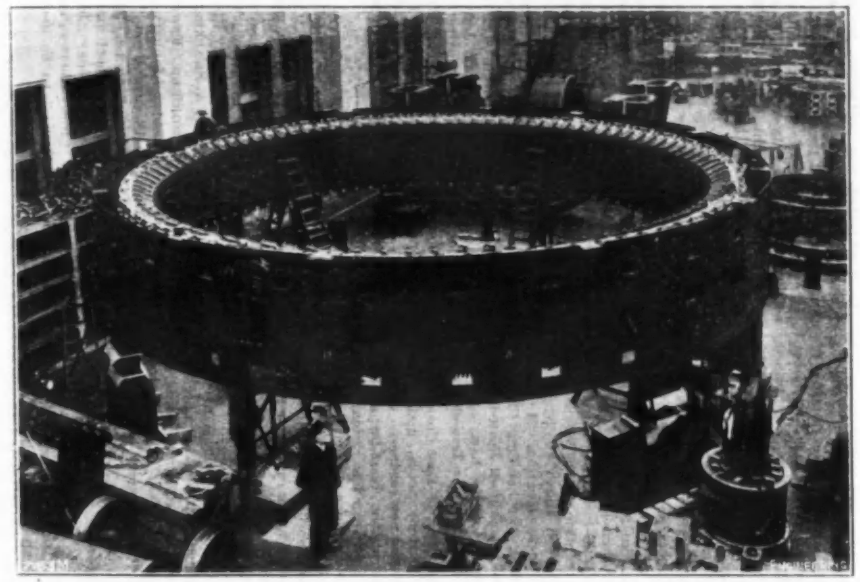


FIG. 13. STATOR FRAME IN SHOPS.

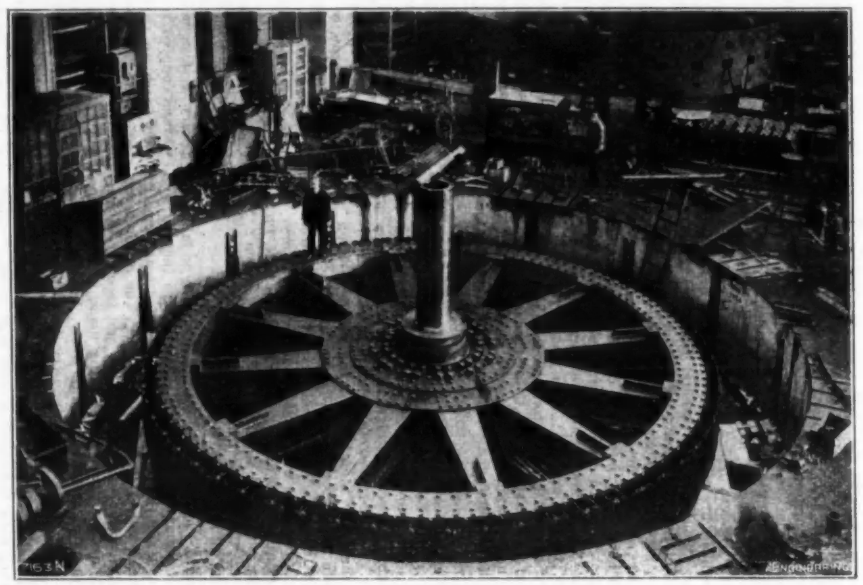


FIG. 14. ROTOR ERECTED FOR SPEED TEST.

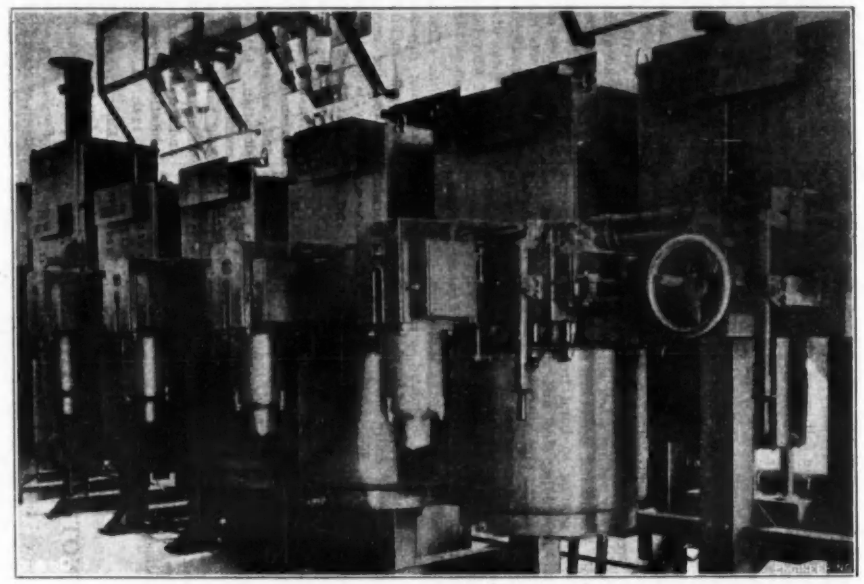


FIG. 15. 11-KV. IRONCLAD SWITCHGEAR.

ENGINEERING.

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ENGINEERING

FRIDAY, JANUARY 12, 1940.

VOL. 149. No. 3861.

PRODUCTION METHODS IN WAR TIME.

CONSIDERABLE dissatisfaction has been expressed at the apparent failure of the Government to take full advantage of the manufacturing resources of the country. In a recent letter to *The Times*, Sir Alfred Herbert, whose position as Controller of Machine Tools during the last war gives weight to his words, referred to the shortage of labour which was holding back our present and future output of munitions and of machine tools alike. He mentioned that less than one half of the machine tools already installed are working at night, because under present conditions labour is not available to complete the night shifts. He maintained that the labour actually existed, a contention that can hardly be disputed in view of the unemployment figures, and that there are thousands of workless men, women, and young people in the country who could rapidly be taught to perform the simple routine operations which form such a large part of present-day methods of mass production. Sir Alfred gave as the reasons that prevented the utilisation of this labour, the existence of Home Office restrictions on the employment of women and young male persons at night, and the fact that there is no broad-scale agreement between the unions and the Government for the encouragement of dilution to its full extent during the war.

Those who remember the extent to which labour dilution facilitated the great output of munitions attained towards the end of the last war will be in complete sympathy with Sir Alfred's viewpoint, and it is regrettable that the major issue he raised is being clouded by the concentration of criticism on the question of the employment of women labour. Thus, in a discussion by union officials of Sir Alfred's contention, reported in *The Daily Telegraph* of December 21, it was claimed not only that there were no rigid restrictions preventing the employment of women, but that the necessity for a widespread influx of women had not yet arisen. We imagine that Sir Alfred would be the first to agree that female labour should not be called upon to a greatly increased extent, except in cases where there exists special aptitude for the work required until the available male labour has been absorbed; and, so far as we are aware, his point has not been answered, that the present organisation of industry on a war footing does not make adequate provision for absorbing this labour. During the last war, a number of instructional factories were set up for the purpose of training unskilled men and women and, later, soldiers and sailors who were disabled to the extent of being unfit for further active service, to take their place in industry. Similar action at the present time appears to be highly desirable. Apart from the existing shortage of labour to complete night-shifts, referred to by Sir Alfred, factories are still in course of erection or conversion, and large numbers of machine tools to equip them are on order, so that unless immediate steps are taken to train the personnel, the labour shortage is likely to become increasingly acute. Sir Samuel Hoare declared, in a recent broadcast, that the job would soon be looking for the man rather than the man for the job, and a prediction to the same effect has been made by the Minister of Labour; but, so far, there is little sign that this millennium for the unemployed is approaching.

Another question, on which the Government has been subjected to considerable criticism, is that of the inclusion of small firms in any general scheme of production. This question, to which we refer elsewhere in this issue, differs from that already mentioned, in that it is mainly a production-engineering problem, and cannot be dealt with simply by relaxing this or that regulation, or by the introduction of new legislation. It may be said at once that, while there are doubtless legitimate grievances on the part of some firms regarding their failure to be awarded government contracts, part of the criticism levelled at the Ministry of Supply is somewhat wide of the mark. It is natural to contrast the large extent to which small firms were embraced within the munition-producing capacity of the country in the last war with the apparent neglect of the same or similar firms to-day; but before too much weight is attached to this comparison, the change in production methods in the interim should be given careful consideration. This change can, perhaps, best be illustrated by considering an industry in which the alteration in production methods is most marked, such as the motor-vehicle industry. At the outbreak of the great war, the annual production of motor vehicles in the United Kingdom was some 34,000, divided among a considerable number of firms. At the time, individuality was almost a fetish in motor-car production, and there was practically no standardisation of parts. Even such items as nuts were frequently of special dimensions, and a wide variety of screw threads was in use. In contrast with these conditions, the output at the outbreak of the present war was well over half a million cars, shared by far fewer firms, a number of the firms existing in 1914 having gone out of existence and others having been amalgamated into larger organisations. The enormous increase in output achieved between the two dates has been largely brought about by the application of continuous-production methods, which were in their infancy in 1914.

Owing to the contrasting conditions outlined above, the conversion of the industry to the production of army vehicles presented quite different problems at the outbreak of the two wars, and, in addition, the Army has been mechanised in the interval. The number of vehicles required has increased enormously; in fact, it was recently stated by Brig. A. S. Crawford, the Director of Mechanisation, that in one works alone we are now producing in a single day as many lorries as the entire British Army possessed at the outbreak of war in 1914. In addition to lorries, special vehicles are now required in very large numbers. The necessary outputs of all types of vehicles required to-day can only be achieved by taking full advantage of the experience in mass production acquired by motor-manufacturing firms, and by a high degree of

centralisation. Continuous production of such a complex mechanism as a motor vehicle is a highly involved process. The factory lay-out must be most carefully planned, the position of every machine being of importance; and the output of each group of machines producing the elements composing a sub-assembly must be exactly proportioned so that no delay is caused in the assembly lines by a surplus or a shortage of components. Another point of great economic importance is that the machines must be of such a type as to ensure that there shall be no wastage of skilled labour.

Bearing these considerations in mind, it will be obvious that the production of parts in a number of small isolated works for final assembly in another works, a method widely adopted in the last war, cannot compete effectively with continuous production in a single works, of a product made up of a large number of components and required in large quantities. The method is practicable, but it is wasteful of man power, and the same rate of output cannot possibly be achieved. Transport is wasted if it is necessary to distribute raw materials to a number of isolated points in relatively small quantities, further waste of transport occurs in passing the manufactured or semi-manufactured components from one factory to another, and a failure to deliver a component cannot be tracked down and righted so quickly as if the whole process of manufacture were effected in one localised organisation. Perhaps the most important objection to this method of production at the present time, however, is that of the waste of man power. This point was particularly stressed by Major-General A. E. Davidson, the Controller of Mechanisation Development, in a recent address, when he pointed out that the methods of production largely employed in the last war involved a waste of skilled men, since it necessitated their employment to a great extent on actual machining operations, whereas their proper position was in the manufacture of jigs and the setting up of tool lay-outs to facilitate the maximum employment of semi-skilled labour. This point will be clearer, perhaps, if the conditions in a small factory be visualised. Such a factory may contain, say, twenty machine tools of varied type, and if the factory has been previously engaged on work of a general nature, a good proportion of these machines will be of a type requiring operation by a skilled man. The proportion of skilled men, therefore, is much higher than in a factory where continuous-production methods are in use, since the latter will be largely equipped with automatic machines where skilled labour is only required for setting up, the actual operation of the machine being effected by a semi-skilled man. It is evident, therefore, that if an output comparable with that obtained from a continuous-production organisation is to be secured by using small independent works, the proportion of skilled labour in the latter system will be much higher. A point not referred to by Major-General Davidson, but equally pertinent to the issue, is that either a much larger number of inspectors would be required in the isolated factory system, or time would be wasted by inspectors travelling from one factory to another.

It may be argued, of course, that many products required by the Navy, Army, or Air Force do not compare in complexity with a motor vehicle, and, therefore, could be manufactured economically in a small works. A shell may be taken as a typical example, since in the last war, a very large output was achieved by utilising small factories to the fullest extent to perform one or more operations on the shell body. The basic advantage of this procedure was that it enabled practically every suitable lathe in the country to be utilised, and did not absorb an excessive amount of skilled labour, since entirely unskilled persons could be quickly taught to carry out a roughing operation. Much delay was caused, however, by defective work, owing to the difficulty of providing the very large number of competent inspectors required, and further delay was caused by the transport of the shells from one works to another as they progressed from the rough billet to the finished product. No doubt there are many products required by the Services which can be efficiently and economically manufactured in a small works, and it is the business of the Minister of Supply to decide on the extent to which such firms can be utilised in the general scheme of war-time production. The primary duty of the Minister is clearly to achieve the maximum output from all the resources available.

THE OPERATION OF HIGH-VOLTAGE ALTERNATORS.

ALTHOUGH more is to be learned from our failures than from our successes, there is a natural tendency to conceal the former from the world and to emphasize the cases where performance has exceeded expectation. This tendency is more marked in the commercial than in the domestic world, partly because it is easier therein to conceal shortcomings and partly because there are good reasons why weapons should not be placed in the hands of a competitor. From the point of view of development generally, however, this attitude has its drawbacks, since it prevents full advantage from being taken of experience that has been gained along either parallel or converging lines. On the whole, then, frankness is to be welcomed, even though this may prove a temporary disadvantage to a firm or individual. We are, therefore, glad to be able to record that publication of details and causes of failures has been much more common of recent years than it was in the past, and though it has been, perhaps, more evident in the United States than in this country, and in this country than elsewhere, we think that any temporary harm that has been caused thereby has been far outweighed by the addition to our knowledge that has been thus obtained. We hope, therefore, that the practice will continue.

The latest example of this technical expansiveness is a paper on "Operating Experience with High-Voltage Alternators," by Mr. W. D. Horsley, which has been released by the Institution of Electrical Engineers for written discussion. This paper reviews the experience which has been gained with high-voltage electrical generation since its introduction eleven years ago. It also gives an account of the difficulties that have arisen with certain of the machines and of the steps that have been taken to overcome them. At the time of its introduction, the generation of three-phase alternating current at a pressure of 33 kV was rightly regarded as a bold experiment. It was also naturally viewed with some misgivings and met with the criticism that the saving in transformer capacity and space occupied, which was thereby possible, would not compensate for the additional risk that was involved. These arguments have received some support from the fact that in the intervening period a substation for raising the pressure to 132 kV has been erected in this country adjacent to nearly every generating station in which large alternators find a home, and that transformers are still required, even when high-voltage generation is employed. On the other hand, the greater attention which is now being paid to the problem of fire risk renders the examination of any means for reducing the amount of oil present in generating stations desirable. This reduction can be effectively secured by eliminating large power transformers.

On the balance, therefore, high-voltage generation has much to recommend it and that this is realised is shown by the impressive list of high-voltage alternators of the concentric-conductor type now in service or in course of manufacture. Altogether, there are 34 such machines, with an aggregate capacity of 1,400,000 kVA, running or under construction. The number of machines of this type actually in service is 21, and up to the present the total machine-years of service is 69. More striking is the fact that of these 21 machines, only four have given any trouble, the remainder having been completely reliable. It should be noted, however, that these figures do not tell the whole story. Mr. Horsley, naturally, deals only with the products of a particular firm which, it is true, was the pioneer in this class of construction, and though this natural omission will undoubtedly be corrected when the comments on the paper are published in the *Journal*, it is only fair to say that other firms are manufacturing high-voltage alternators and that we believe that their experiences have been no less favourable than those recorded. Perhaps, also, we should mention that this is a British pioneering effort and that, in due time, it will appear that our example has been widely followed.

Of the machines on which failure occurred, the first to be mentioned by Mr. Horsley is a 25,000-kW unit, which was installed in the Brimsdown station of the North Metropolitan Power Station Company in May, 1932. After 55 hours in service, the insulating tube between an outer conductor and the core failed, probably owing to a flaw. The chief lesson to be learnt from this occurrence was the rapidity with which the conductor bar could be replaced. A second breakdown of the same kind, and due to the same cause, took place in May, 1938, but since then the possibility of repetition has been largely avoided by improved methods of manufacture. In November, 1933, a flash-over took place from the end windings to the stator frame, and simultaneously a flash-over to earth occurred from one terminal on the oil circuit breaker controlling the alternator. Examination showed that this was due to an extremely high over-potential, which was, in turn, due to the phenomenon known as neutral inversion or neutral instability.

This instability, which has already been described and analysed in several technical papers, is a complex form of resonance and is liable to occur when a three-phase alternator, or other apparatus with windings and connecting cables of appreciable capacitance to earth, is earthed through the neutral point of an instrument transformer. It is not widespread, even on lower voltage systems, and actually has only occurred on three high-voltage alternators, two of which are those installed at Brimsdown. There are several methods of preventing it, the best being to earth the star point of the voltage transformer. At Brimsdown, however, this course could not be adopted, as the voltage transformers were single-phase units housed in separate tanks and forming part of the main circuit-breaker panel, which was of the metal-clad phase-isolated type. In this type of switchgear the neutral end of the primary winding of each unit is connected internally to the earthed enclosure, and it would only have been possible to bring out an insulated connection to a neutral point by fitting an expensive bushing in each transformer chamber. Fortunately, the earthing of the alternator neutral through a comparatively low resistance or reactance is an equally satisfactory solution to the problem, though this was only possible at Brimsdown when the machine was running excited and disconnected from the system. The details of the arrangement adopted are given in the paper, and, it is claimed, ensure that neutral inversion can only occur during the brief period when the alternator is running excited after it has been disconnected from the system by the protective gear.

After the experience with neutral inversion at Brimsdown, precautions were taken to avoid a repetition on other high-voltage alternators having voltage transformers with the neutral point of the primary winding earthed. At the Salt River station, near Cape Town, the precaution was initially taken of earthing the alternator neutrals whenever the machines were running excited and disconnected from the 'bus bars, but after a time they were left isolated under all conditions, since it was considered that instability was unlikely to occur in practice. After the plant had been in operation for two or three years, however, flash-overs occurred across the bare-lead extensions of two of the alternators and extended to the end windings, where much damage was caused. At first, no evidence of weakness was found in the windings, but after a second failure had occurred, careful examination of the third set disclosed small arc craters, which were unmistakably caused by flash-overs, in the metal bases of the insulators supporting the lead extensions. The existence of high over-voltages was, therefore, confirmed and the only explanation that seemed to fit the facts was that once again neutral instability had occurred when the alternators were de-excited after coming-off the bars, thus causing a high voltage between the windings and earth. Neutral inversion would, of course, be likely to develop with a change in voltage and as the alter-

nator field died away, the duration of a sustained arc would be limited to a short period. The practice of earthing the alternator neutral while it was disconnected from the bars was therefore reinstated and the voltage transformers were loaded with a resistance burden connected across the open delta secondary winding of an auxiliary transformer. In addition, a new type of lead extension insulator was fitted and the leads were insulated throughout their length. The subsequent results have been satisfactory.

The last breakdown described by Mr. Horsley occurred on the end windings of one of the two 33-kV alternators at Tir John North Station, Swansea, and was due not to neutral inversion but to a defect in the manufacture of the bushes used at this point. A shortage of ventilating air, resulting in uneven cooling of the windings, was a contributory factor, while the temperature level was generally high. It is, perhaps, hardly necessary to say that these and other difficulties that have been experienced have been utilised to bring about a general improvement in design which may be grouped under the headings of conductor and joint insulation. Only one fault has occurred from the breakdown of the conductor insulation, and this type of mishap is now being guarded against by the use of improved methods of testing and inspection during manufacture. In addition, the system of impregnation has been modernised, with the result that the breakdown strength and limit of stability have been appreciably increased. Finally, improvements have been effected in the making of the micanite sheets with which the conductor insulation is built up. Similarly, the construction of the insulating bushes has been improved by adopting the method used for commutator Vee rings. In this, the bushes are built up of several layers of overlapping strips of micanite which have been previously punched out of sheets to the required shape. They are then heated and placed in a mould which bends them to the right curvature and are subsequently assembled by hand. The loosely assembled bush is again placed in a mould, so that the finished product is of uniform thickness within very close limits. Though the form of construction has not been changed fundamentally, a number of detailed modifications have been made and a new technique has also been developed for making and insulating the joints. Among other things, glass silk, which has the advantages of being inorganic and inert, is being used as an insulating material.

Enough has been said, perhaps, to show that the views expressed by the critics of this development were unnecessarily timorous and that this experiment, for such it initially was, has been justified by results. It is true that changes have been necessary, but these have been neither more numerous nor more profound than would be expected with any engineering novelty. We may, therefore, support Mr. Horsley's contention that the principle of the design is sound. It will be interesting to see whether its use eventually becomes more general.

NOTES.

GOVERNMENTAL CHANGES.

ALTHOUGH it is not within our province to deal with political questions, perhaps we may comment on two of the important changes in the Government which took place last week. The school which argues that new recruits to the Cabinet might be drawn, for the sake of strength, from other than purely political circles will be encouraged by the appointments of Sir Andrew Duncan and Sir John Reith as President of the Board of Trade and Minister of Information, respectively, while those who hold that engineers might and should play a more prominent part in the work of government can feel that at least a step has been made in that direction; for though Sir Andrew Duncan is not an engineer, he has worked closely with engineers and, therefore, may be expected to understand something of their outlook and mental processes. From 1927 to 1934 he officiated as the first chairman of the Central Electricity Board and since that time he has been independent chairman of the Executive Committee of the British Iron and Steel Federation. In the first position he had the difficult task of co-ordinating a number of the differing policies and opinions that then existed in the electricity supply industry and, while he had the forces of compulsion behind him, it is generally acknowledged that he carried out these duties with insight and tact, while the speed with which the "grid" was erected and the other necessary changes made are a tribute to his drive. More recently, these qualities have been of equal value in the re-organisation of the iron and steel industry, while earlier he gained useful experience as Coal Controller and as vice-chairman of the Shipbuilding Employers' Federation. Sir John Reith is probably even better known to the public as the first general manager of the British Broadcasting Company and, from 1927 to 1938, as Director-General of the British Broadcasting Corporation. While holding those positions he has doubtless become accustomed, if not insensitive, to criticism, and it is probable that he will find the training he has received most useful in his new work. Sir John has the reputation of being an autocrat, but we have only to consider what broadcasting might have become in this country under a control inspired by less high and rigid ideals to realise that there may be good points about even autocracy. It will be interesting to see whether he can make the Ministry of Information more popular than it has been among those who come most directly under its influence.

GERMANY'S EXPORT TRADE.

The special correspondent of *The Times* in Rotterdam has given an account, which should be widely studied, of the efforts that are being made by Germany to maintain her export trade in spite of the war. These efforts, of course, are primarily organised to enable her to buy the foodstuffs and raw materials which she needs, but undoubtedly they will have the further result of maintaining her goodwill in those markets where we are one of her principal competitors. It is with this end in view, primarily, that industrial mobilisation has been carried out to the greatest extent and attempts are being made to fit every available German to perform some productive job. On the outbreak of war, those who were engaged in comparatively simple or nationally unimportant work, but who had training in, or knowledge of, some more vital or less usual craft were transferred, leaving their places to be filled by amateurs. Elderly specialists were brought out of retirement and able-bodied women of all classes were trained to work on munitions. All the principal necessaries of life, not only food, have been rationed so as to have as large as possible a margin of raw materials with which to work for export. No export order which Germany can obtain from a foreign country, it is stated, is refused. Field guns have even been exported to Holland, with whom an increasing trade in other commodities is being maintained, and the same is true of Italy, Switzerland, and other countries. It is, perhaps, hardly necessary to add that the weapon of propaganda is also being used, one of the stock arguments being that, while Germany is maintaining normal trade relations with her neighbours, Great Britain, by the blockade, is wrecking the trade of the world. Further, it is pointed out that Germany is so well organised internally that she can wage war and carry on normal trade at the same time; Great Britain cannot. There are many engaged in the trade of this country who could confirm the indictment which is implied in this argument. It is to be hoped that active steps will soon be taken to restart important parts of our industrial machine to which the brake has been mistakenly and too vigorously applied, in order to provide the most effective reply to allegations of this kind.

THE GOVERNMENT AND SHIPPING CONTROL.

An important announcement regarding the future operation of British mercantile tonnage engaged in the deep-sea liner trades was made on January 4 by Sir John Gilmour, the Minister of Shipping, to representatives of the Chamber of Shipping and of the Liverpool Steam Ship Owners' Association. The Government had decided, Sir John stated, to extend the requisitioning of ships, at present only applied to tramp tonnage in certain trades, to all ships in the liner trades, on the United Kingdom and Colonial registers, as from February 1, 1940. The method of control is to follow generally that adopted in the last war, and is expected to effect considerable economies in the use of the available tonnage. The owners of the ships are to remain responsible for the crews and upkeep of their own vessels and, as far as possible, will continue to operate them, subject to official instructions as to cargoes and the routes to be taken. Two special branches, directed by experienced ship-owners, are to be formed in the Ministry for the regulation of the requisitioned tonnage, but the shipping companies will continue to maintain their own organisations at home and abroad. Accounts will be rendered to the Ministry of all voyage receipts and expenditure, and the profits or losses will be treated as arising on Government account. No indication was given, we understand, of the conditions of charter or the rates to be paid for the use of the ships, but these are to be settled by discussion in the near future. It is intended that the control shall apply to individual ships from the date when they complete their first discharge in the United Kingdom after the scheme comes into operation. The suddenness of the decision announced by the Minister, and the fact that there has been no previous discussion of the terms on which the requisitioning is to be carried on, have aroused a considerable amount of adverse comment in shipping circles, where it is felt that the possibilities of control by means of licences and a supervisory direction of voyages have not yet been fully explored. It may be recalled, however, that, in the last war, it was a report of the Ship Licensing Committee, upon the difficulties that they were experiencing in finding sufficient tonnage to meet all the requirements of the Allied Governments, which led to the appointment of the Shipping Control Committee in January, 1916, under the chairmanship of Lord Curzon. It would appear, therefore, that the Government is only taking a step, voluntarily, which was forced upon them in the last war by pressure of circumstances that they might reasonably expect to recur in this, if the tempo of hostilities quickens. Fortune has dealt hardly with the British shipping industry in the last twenty years, and it is natural that it should view with suspicion an innovation introduced in this apparently arbitrary manner; but everything turns upon the degree of departmental interference that may be permitted under the guise of "control," and it would be unwise to assume at the present stage that the executive heads of the Ministry have learned nothing, in this respect, from the experience of the previous war. The magnitude of the task involved by a wider and more unified shipping control necessitates close co-operation with the actual owners, because they alone have the knowledge to make the control effective; and this point can hardly have been overlooked by the Minister's expert advisers.

HIGH-SPEED ELECTRIC-TRAIN RECORD.

A detailed account of a remarkable run, which was made on July 20, 1939, by an electrically-driven train between Florence and Milan on the Italian State Railways is given in the current issue of *Rivista Tecnica delle Ferrovie Italiane*. On this run, the distance of 195·8 miles between the two cities was covered in 115·2 minutes, an average speed of 101·8 m.p.h. A maximum speed of 126 m.p.h. was attained. The train consisted of a three-car unit, weighing 107½ tons empty and 120 tons with a full complement of passengers and baggage. The only difficult section of the run is that between Prato and Bologna, over the Apennine direct line. From Prato to Vernio the line rises on an average gradient of 1 in 106 for 12¾ miles, and there are also numerous curves, but the test train negotiated these at speeds of from 82 m.p.h. to 90 m.p.h. From Vernio to the Apennine tunnel, which is 904 ft. above Florence and 1,058 ft. above sea level, the gradient eases and through the 11½-mile length of the tunnel itself the speed rose from 99 m.p.h. at the entry to 109 m.p.h. at the exit. From Vado at the tunnel portal to just before Bologna the speed ranged from 93 m.p.h. to 112 m.p.h. down a gradient which at first averages 1 in 94 for 9½ miles and then flattens out. The 60·2 miles from Florence to passing Bologna were

run in 39 minutes. From Bologna, which is only 144 ft. above sea level, to Lodi, a distance of 113½ miles, the gradients are negligible, while the last 22 miles to Milan are on a rising gradient of 1 in 680. The speed over this part of the journey was chiefly between 90 m.p.h. and 102 m.p.h., the start-to-stop average for the entire 195·8 miles from Florence to Milan being, as stated, 101·8 m.p.h.

Small Firms and Government Contracts.

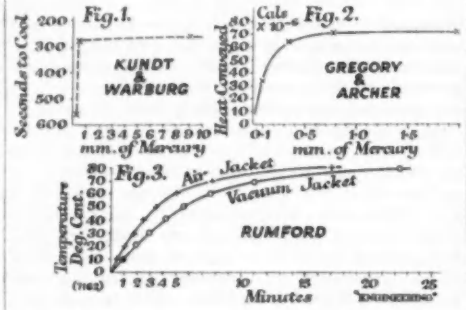
At a recent conference, Mr. Burgin put forward certain arguments in reply to the criticism that small firms were at present being neglected in the allocation of Government contracts. The organisation of such firms, he said, often made it impossible for them to supply the articles required in sufficient quantities sufficiently quickly, while inspection was more difficult owing to scattering, and to deal with a number of different managements also led to a waste of effort. At the same time, he recognised the principle at stake, and promised to see that these concerns obtained their fair share of the work. This object, which, apart from other reasons, is desirable from the point of view of the prosperity of the economic life of the country, should be assisted by the recent formation of a national association with the title of the Federation of Manufacturers and Producers of Great Britain. The decision to establish such a body was taken at a meeting in London last week, which was attended by the representatives of no less than 1,500 firms. The immediate purpose of this organisation is to approach the Minister of Supply on the question of war contracts and to promote the general interests of the smaller manufacturers and producers of Great Britain and the Empire. A council appointed by the members is to be appointed and will be assisted by branch committees representative of the various trades. There will be 13 of these branch committees throughout the country, in areas which will correspond with those set up by the Ministry of Supply. A further object of the Federation will be to increase the proportion of contracts allocated to small firms above the 10 per cent. promised by Mr. Burgin, and to ensure that these contracts are granted as the result of tendering, and not by what is described as favouritism. The procedure suggested is for groups of small manufacturers to appoint a parent firm to tender and be responsible for the carrying out of the contract when placed. The experiment will be watched with interest; at least it is on the right lines.

Postponement of the Manchester-Sheffield Railway Electrification.

At the beginning of the week the not unexpected announcement was made that it had been decided to postpone further work on the conversion of the main line of the London and North-Eastern Railway between Manchester and Sheffield from steam to electric traction, on completion of the contracts that have already been let. In all probability, regrettable as this is, it is the only course that could have been taken at the present time; for both the labour and material necessary for this work are more urgently required for war purposes, and to continue with a large volume of reconstruction on an important channel of communication would only add to the difficulties imposed by wartime traffic conditions and the black-out. As it is, we understand that over half the civil engineering work necessary for the conversion has been completed, and several miles of overhead structures for carrying the 1,500-volt direct-current trolley wires have been erected. The erection of special overhead equipment in the Woodhead Tunnel has been begun and the construction of the new steam and electric locomotive depot at Darnall near Sheffield is well advanced; while a new fly-over bridge across the main lines at Sheffield to enable locomotives to pass from the up side to the Darnall locomotive depot has been built. Orders have also been placed for rolling stock and electrical equipment for the locomotives. The postponement of this conversion scheme, which we hope will not prove lengthy, is unfortunate in that it was the first true main-line electrification to be carried out in this country, and because locomotives were to be used for the haulage of both passenger and freight trains. It comprised 74·6 miles of route and 292·7 miles of track, including some fairly steep gradients and the twin tunnels at Woodhead, just over three miles long and the capacity of which is seriously limited by smoke.

THE DEVELOPMENT OF THE VACUUM FLASK.

In the course of two lectures which he delivered at the Royal Institution on December 7 and 14, respectively, Sir William Bragg said that the vacuum flask, with its many industrial and domestic uses, was one of the fruits of scientific advance which was now taken almost for granted, but behind its development there was a long history of research and experiment. Its practical application was largely due to Sir James Dewar, but in this advance Dewar might be said to have been an inventor rather than a discoverer, in that he worked out no new principle or law but applied to the solution of a practical difficulty the results of previous investigations which had been commenced a century before his time. Dewar was engaged in studying the behaviour of gases below the temperature at which they liquefied. As this temperature is about 200 deg. C. below the freezing point of water, the liquefied gases boiled away very rapidly if placed in an ordinary receptacle, and, further, the intense cold led to the formation on the exterior of the vessel of a deposit of frost which prevented the behaviour of the contents from being observed. The formation of frost could be prevented by placing the liquid in the innermost of a series of vessels



through which the evaporating gas was led in order, all being protected by an outer vessel containing some dehydrating material. This arrangement also served to slow down evaporation, as the liquid gas at the centre was surrounded by several jackets of gas at a low temperature. Examples of such vessels are still preserved at the Royal Institution, where Dewar's work on low temperatures was carried on, but evaporation from these vessels was still far too rapid to permit experiments of long duration to be performed; still less was it possible to maintain any storage of liquefied gases. The solution to this problem was only reached with the development of the high-efficiency vacuum flask.

There were three methods, the lecturer said, by which the balance of heat between bodies at different temperatures was regulated, viz., convection, conduction and radiation, and to maintain a substance for long periods at a temperature different from that of its surroundings, all these must be eliminated as far as possible. Convection ceased in an evacuated space as soon as the number of molecules of gas became insufficient for their movement in streams or masses; but since conduction occurred through the successive collisions of molecules, this persisted so long as the mean free path of the molecules of gas was definitely less than the dimensions of the evacuated space. This was illustrated with the aid of a billiards table covered at first with balls in random arrangement at about three times their own diameter apart. The balls were gradually removed in a manner which preserved the random arrangement, but until the table was almost cleared there was little chance of any ball being rolled from end to end without a collision occurring.

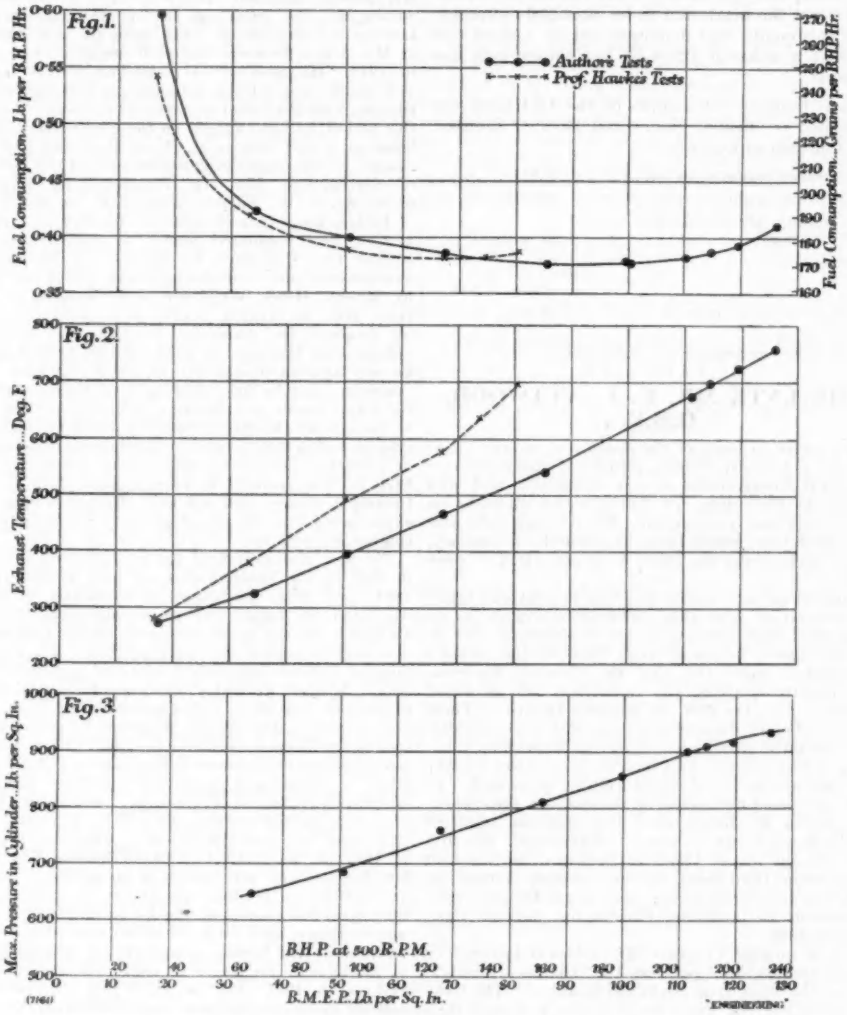
The effects of convection and conduction and their elimination were demonstrated by an experiment in which a small heating coil and a thermo-junction were mounted at opposite extremities of a glass bulb which could be evacuated. The current from the thermo-junction was made to actuate a mirror galvanometer, a spot of light from which was thrown upon the screen. It was seen that, with the bulb evacuated, the heating of the coil produced no movement of the spot, but as soon as a small quantity of air was introduced, the spot at once indicated a transference of heat to the thermo-junction. The amount of this remained steady throughout a considerable increase of pressure, but rose steeply as the pressure approached that of the atmosphere. The first movement of the spot, which occurred as soon as a very small amount of air was admitted, was due to conduction and did not increase with increasing pressure. The sudden much greater movement of the spot as the pressure approached that of the atmosphere, however, marked the moment at which convection began to act freely. Thus, while convection was easily prevented, conduction was not really eliminated until a good vacuum was obtained.

These facts were well illustrated by plotting graphs of the observations made of heat transference with varying pressure. Such graphs, examples of which are given in Figs. 1 and 2, had a characteristic shape. At pressures well below one millimetre of mercury there was a rapid increase in the amount of heat transferred for a very small increment of pressure; the curve then flattened out and remained almost horizontal over a wide range of increasing pressure until the pressure approached that of the atmosphere, when it again rose steeply. The final steep rise of the graph, not shown in Figs. 1 and 2, corresponds to the commencement and increase of convection, the nearly horizontal central part to the persistent effect of conduction, while the first steep rise showed the commencement of conduction as the pressure increases above the very low value at which transference took place only by radiation. It was only at this lowest pressure that a vacuum flask could be effective.

The researches which eventually led to these conclusions had their beginning at the end of the Eighteenth Century, when the problem of the true nature of heat was being discussed. Herschel had shown that heat was transmitted by rays beyond the red end of the visible spectrum and that these rays could be focused by a lens. Leslie opposed the theory of heat as a mode of motion and sought to prove that it was a fluid. It was doubtless in an attempt to settle this controversy and to discover the truth about the nature of heat that Count Rumford, one of the founders of the Royal Institution, began a series of experiments on heat transference. In the course of these, he investigated the effect of placing a thermometer bulb in a vacuum and compared the time taken by the thermometer to rise to a certain temperature with that taken by a thermometer the bulb of which was surrounded by a vessel similar to the vacuum vessel but containing air. Fig. 3 has been plotted from his results as he published them. Rumford placed the vessels in a freezing mixture until the thermometers registered freezing point and then plunged each into boiling water and noted the time taken for the thermometer in each to rise to a given temperature. Rumford's results were not so satisfactory as those of later workers, since the Torricellian vacuum, which was the best he could obtain, was insufficient to prevent conduction entirely. Further, by regarding only the total time taken in each instance, he showed his results in the least favourable light; the difference between the initial rates of cooling of the vessels was far more striking as the initial slopes of the curves plotted from his results showed.

In the course of Sir William Bragg's lectures, two experiments similar to Rumford's were carried out. In the first, two small bulbs filled with coloured fluid were immersed in hot water, one being surrounded by a vacuum jacket. It was seen at once, by the expansion of the coloured fluid up narrow tubes fitted to the bulbs, that the rise of temperature was much slower in that surrounded by the vacuum jacket. To secure exact similarity to the experiment of Rumford, the second bulb should have been enclosed in a jacket of air; but it was demonstrated that the omission of this measure was of

TESTS OF A PETTER SUPERSCAVENGE ENGINE.



TESTS ON A PETTER SUPERSCAVENGE ENGINE.

R.p.m.	501	497	499	503·5	501	499	499	499	499·5	490	500
B.m.e.p., lb. per sq. in.	17·4	34·4	50·5	67·6	85·3	99·6	100·1	111·2	114·6	119·5	126
B.h.p.	32·4	63·9	93·9	126·9	159·2	185·4	186·0	205·2	213·4	222·1	234·3
Fuel, lb. per b.h.p. per hr.	0·597	0·446	0·399	0·383	0·376	0·377	0·376	0·382	0·386	0·392	0·409
Exhaust temp., deg. F.											
Cyl. 1	284	329	387	465	536	612	612	660	682	708	744
Cyl. 2	260	320	396	469	545	626	626	684	714	736	772
Maximum cylinder pressure, lb. per sq. in.	—	648	685	760	812	859	—	900	910	918	932
State of exhaust	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Just Visible	Slightly Black

comparatively slight importance, for, when air was admitted to the evacuated jacket, the rate of increase of temperature became almost the same in each bulb. The second experiment comparable to that of Rumford was a repetition of an early experiment of Dewar himself, and for this the double vessel employed was that actually used in the original experiment. In this experiment, the heat transference was indicated by the evaporation of liquid oxygen, the rate of this being measured by the displacement of water in an inverted tube. With the evaporating gas surrounded by a vacuum, the water in the tube was all displaced in about 14 seconds, but when the vacuum was destroyed the rate of evaporation increased enormously and the tube was filled in less than 2 seconds.

These experiments showed that the plain vacuum vessel was effective in preventing convection and conduction, thus dealing with two of the three methods of heat transference mentioned above. There remained, however, the problem of radiation. For Dewar's work at very low temperatures this was particularly important since the effect of radiation becomes relatively greater as the temperature difference increases. This final problem was solved by silvering the inner surfaces of the vacuum vessel. The efficiency of silvering in stopping the entry of heat by radiation was demonstrated by using a cylindrical vacuum vessel of which only one-half of the interior surfaces was silvered. This was half-filled with liquid oxygen and placed near a thermopile connected to a spot galvanometer. As the silvered and unsilvered sides of the vessel were turned successively to face the thermopile, large movements of the spot showed clearly that far more heat was being absorbed by the liquid gas through the unsilvered than through the silvered side of the vessel. This was further demonstrated directly by employing a pair of vessels having a common vacuum of which one was silvered and the other plain. These were partly filled with liquid oxygen and the evaporating gas from each could be collected by displacing water in similar inverted tubes. When the latter were simultaneously moved over the ends of the tubes leading from the vacuum vessels, it was seen that the rate of evaporation from the unsilvered vessel was four times greater than that from the silvered vessel.

The silvered-glass vacuum vessel, Sir William remarked, formed a satisfactory solution to the problems of the laboratory handling of liquefied gases. The industrial use of the vacuum vessel, however, introduced a new problem. For the storage of liquefied gases, the most efficient size of vacuum vessel was one of about 5 gallons capacity. This, however, was considerably larger than could conveniently be made of glass, and, further, when it was necessary to transport the vessels a material less fragile than glass must be employed. These requirements led to the development of the metal vacuum vessel. With this, a new difficulty was encountered; it was not possible to produce such a high vacuum in a metal-walled vessel as in a glass one, since a certain amount of gas was occluded in the metal, and as this slowly escaped the vacuum gradually deteriorated. This final problem was solved by the use of charcoal, which was a powerful adsorbent of gases, its efficiency, conveniently, being increased at low temperatures. The adsorbent power of charcoal was demonstrated by one of Dewar's own experiments, the original apparatus used by Dewar himself being again employed. In this experiment a barometer tube was mounted beside a second tube dipping in the same mercury but filled with air. The top of this second tube, which was sealed, was bent twice at right angles and in the short vertical closed arm thus formed some coco-nut charcoal was placed. When this charcoal tube was surrounded by liquid oxygen the mercury began to rise in the empty tube and within a short time had risen to within a millimetre of the height of the barometer. It was clear from this that the adsorptive power of the charcoal had increased so remarkably when its temperature was lowered to that of liquid oxygen that it had been able to absorb practically all the air originally contained in the tube.

By taking advantage of this property of charcoal, the lecturer stated, very efficient metal vacuum vessels could be made. The charcoal was placed in a capsule or tube open to the vacuous space, and attached to the inner vessel, and, therefore, its efficiency rose precisely when it was required to do so, *i.e.*, when the vessel was in use and the temperature of the inner vessel, and consequently of the charcoal, was lowered to that of the liquid gas contained in the vessel. The charcoal, thus cooled, rapidly condensed the traces of gas that had escaped from the metal walls and so maintained the vacuum at its necessary value. The useful properties of the container were further increased by giving a high polish to the metal surfaces of the interior of the vacuum shell before assembling it.

IMPROVED RESULTS FROM A PETTER SUPERSCAVENGE ENGINE.

By S. J. DAVIES, D.Sc.

A TWO-CYLINDER Petter Superscavenge engine, built by Messrs. The Brush Engineering Company, Loughborough, in accordance with the Kadenacy patents, under licence from Messrs. Armstrong Whitworth Securities Company, Limited, has recently been the subject of various improvements at the laboratories of the latter company at Slough, Bucks. The results with the original engine were already of a high standard, both as regards output and consumption; but after further development it was found possible to improve the correlation between the exhaust processes and the admission processes following the Kadenacy principle without sensibly modifying the general design of the engine. The present report gives the results of tests carried out by the author on the improved engine on December 20, 1939, at Slough. The Petters Superscavenge Diesel engine was the subject of an article in ENGINEERING, vol. 146, page 10, (1938), and data obtained from tests made by Professor C. J. Hawkes, in June, 1938, were also given in that article. Certain of these data will be included here, since they provide a useful standard of comparison for the results of the present tests.

In view of the description given in the earlier article, it is only necessary here to summarise the principal features of the engine under test. This engine carried the makers' No. 2RA-004, and had two cylinders, of 8½ in. (215·9 mm.) bore and 13-in. (330·2 mm.) stroke, giving a total swept volume of 24·1 litres. Single-acting on the two-stroke cycle, its rated output was 125 brake horse-power at 500 r.p.m., corresponding to a brake m.e.p. of 67·1 lb.

per square inch. The admission ports are controlled by the piston and there are two exhaust valves in the head; the passage of the gases through the cylinder is thus uni-directional. The admission air is supplied by a Zoller type of rotary blower, chain driven from the engine. The combustion chamber is of the open type, with one centrally-placed fuel-injection nozzle; the fuel-injection equipment is of C.A.V. manufacture.

The engine was coupled for test to a Heenan and Froude hydraulic brake, which the author had previously checked. The fuel was measured by observing the time to consume calibrated volumes, the density of the fuel being measured by hydrometer to give the necessary conversion of the volumes to weights; the number of revolutions of the engine was simultaneously recorded by tachoscope during the observed time to consume the calibrated volume of fuel. The leakage of fuel, which should be of the order of 0·003 lb. per brake horse-power per hour, was not measured. The fuel used was Pool gas oil, and an independent report on this fuel is given at the end of this report. The temperatures were recorded by calibrated mercury thermometers. The maximum pressures in the cylinder were recorded by a Sunbury cathode-ray oscillograph, using the calibrating disc valve and a pressure gauge; this gauge was checked afterwards against a master gauge that had been tested at the National Physical Laboratory, and the readings corrected. The lubricating oil was not measured. The barometer stood at 30·2 in. of mercury and the air temperature ranged from 55 deg. to 59 deg. F.

One series of tests only, at constant speed and increasing load, was run on this engine. The governor was out of action during the whole series. In each test the engine was under observation as regards steadiness of conditions during at least 20 minutes. The data from the tests are given in the table on page 43. Fig. 1, on the same page, shows the values of the fuel consumption in pounds and in grammes per brake horse-power per hour, plotted on a base of brake m.e.p., and of brake horse-power at 500 r.p.m. On Fig. 2 are plotted the mean exhaust temperatures on the same base. On both these figures are added, in broken lines, the corresponding values of the quantities recorded by Professor Hawkes in June, 1938, on a four-cylinder engine of the same general design and dimensions. In any comparison of the curves account must, of course, be taken of the probably superior mechanical efficiency of the four-cylinder engine. Fig. 3 shows the maximum pressures in the cylinder, also plotted on the same base.

The most striking improvement to be recorded is in the figures of output as shown in Fig. 1. For a true comparison of practical performances, complete knowledge would include the exhaust temperatures, the maximum pressures in the cylinder and the piston temperatures. The latter are, of course, extremely difficult to measure, and fall outside ordinary shop tests; the other data are given in Figs. 2 and 3. It is seen that, for the same value of the exhaust temperature, taking 690 deg. F., the brake m.e.p. has been increased from 80 lb. to 114 lb. per square inch, an increase of 42·5 per cent. A similar comparison in terms of maximum pressure is not possible, but the curve of Fig. 3 shows that a brake m.e.p. of 126 lb. per square inch was recorded with the moderate maximum pressure of 935 lb. per square inch. It is thus clear that the pressure and heat loading are in no way excessive.

A noteworthy feature of the curve of Fig. 1 is the extremely wide range of output over which the specific consumption is very low: for example, from 85 brake horse-power to 230 brake horse-power, that is, from 50 lb. to 123 lb. per square inch, brake m.e.p., the specific consumption does not exceed 0·4 lb. per brake horse-power per hour; further, over the range from 75 lb. to 107 lb. per square inch, brake m.e.p., the specific consumption is slightly less than that recorded by Professor Hawkes. Reference to the last line of the table shows that the state of the exhaust was extremely good throughout. The "limit of satisfactory exhaust" certainly lay above 120 lb. per square inch. The author was not entirely satisfied with the observation of this on the day in question, since, with a grey sky, darkness was falling. He, therefore, asked for a repetition of this part of the test on the following day, when, against a clear sky, he found his observations completely justified. That 126 lb. per square inch is not the maximum to be ultimately expected from this engine was demonstrated by a short test in which a value of 128·4 lb. per square inch was recorded.

Fuel Analysis.—A sample of the fuel used was submitted to Messrs. Moore and George, Limited, who reported as follows:—

Specific gravity at 60 deg. F. ...	0·847	
Closed flash point (Pensky Marten)	184 deg. F.	
Viscosity (Redwood No. 1) at 100 deg. F.	34 seconds	
Cetene No.	60	
	Gross	Net
Calorific value, B.Th.U.	19,634	18,353

THE LATE MR. E. L. ATTWOOD, O.B.E.

WE regret to learn of the death, on January 1, of Mr. E. L. Attwood, O.B.E., formerly Deputy Director of Naval Construction at the Admiralty and well known as the author of several standard works on ship design and construction. Mr. Attwood, who was in his 69th year, retired from the Admiralty in January, 1932, having held the office of Deputy D.N.C. since 1930.

Edward Lewis Attwood was born in 1871 and began his association with ship constructional work as an apprentice at the Blackwall yard of Messrs. R. and H. Green. Later, he spent some time at the Thames Ironworks, under the late Mr. Clement Mackrow, concurrently studying the theoretical side of naval architecture at the Bow and Bromley Institute. There he showed marked aptitude and, in 1892, won a scholarship for three years, granted by the Worshipful Company of Shipwrights, by which he was enabled to take a course at the Royal Naval College, Greenwich. In 1895 he passed out second in the list, Mr. (afterwards Sir) Arthur W. Johns being first, and was admitted to the Royal Corps of Naval Constructors. His first appointment was to Chatham Dockyard, as Assistant Constructor (third class), but this was of short duration, as he was transferred to the Admiralty in the same year. Promotion to Assistant Constructor (second class) came in 1899.

For a number of years Mr. Attwood lectured on naval architecture, both at the Thames Ironworks and at the West Ham Technical Institute. The latter course of lectures, which he continued to deliver there for some 12 years, formed the basis of his first and probably best-known book, the *Textbook of Theoretical Naval Architecture*, which was published in 1899. It has since passed through many editions, being still regarded as a standard work, and may be supposed to have influenced its author's subsequent appointments, in 1901, as lecturer at the Royal Naval College and, in 1904, as Instructor—the senior College appointment, now a professorship, which he retained until 1907. In 1904, also, he completed a second book, *Warships*, intended primarily for naval officers. Mention may be made here of a small handbook of a more popular character, entitled *The Modern Warship*, which he produced in 1913; and of the excellent manual on *Laying Off*, written jointly with Mr. I. C. G. Cooper, a new edition of which was reviewed on page 56 of our 147th volume (1939). Both of the last two books have been translated into foreign languages.

In 1909, Mr. Attwood was transferred to the Tyne as principal overseer at the shipyard of Messrs. Palmers Shipbuilding and Iron Company, where he remained for three years, supervising the construction of the Dreadnought battleship, Hercules, and the battle cruiser, Queen Mary. Before the completion of the latter vessel, however, he was recalled to the Admiralty and appointed, first, to the staff of the Superintendent of Contract Work and, shortly afterwards, to that of the Director of Naval Construction. In the same year, 1912, he was promoted Constructor. He did not leave Whitehall again. He was made Chief Constructor in 1919, and in 1924 was appointed Assistant Director, holding this position until 1930. When, as stated above, he became Deputy Director of Naval Construction. Mr. Attwood joined the Institution of Naval Architects in 1897, and was elected to the Council in 1930, but his only contribution to the *Transactions*, apart from participation in discussions, was a paper on "The Admiralty Course of Study for the Training of Naval Architects." On this subject he will be remembered by many colleagues and former students—in many cases the terms are co-applicable—as a teacher of marked lucidity who was, at the same time, a practical naval architect of skill and distinction.

THE LATE MR. J. E. DOWSON.

ON Wednesday, January 3, the veteran gas engineer, Mr. Joseph Emerson Dowson, died at Hartfield, Sussex, at the great age of 95. He was born in London on September 26, 1844, being the elder brother of Mr. Alfred Dowson, the civil engineer, who died in 1914. He received his schooling at the Lycée at Versailles and at Dulwich College, and his engineering training with his father on contracting work. During this period, he was engaged on the construction of the breakwater and railway at Herne Bay, and had sole charge, for the engineering contractors, of the building of Scarborough pier. He completed his pupilage under Mr. E. W. Hughes, M.Inst.C.E., on the design of bridges and other structures. In 1870 he and his brother were appointed jointly as engineers to the Redcar Pier Company, for whom they designed a wrought-iron pier 1,000 ft. in length, which was built by Messrs. Head, Wrightson and Company. Two years later he visited Ceylon and India to report on projects for tramways in Colombo, Bombay, Calcutta and Madras. In 1873, with his brother again, he was appointed engineer to the Cleethorpes Pier Company, and in the following year he reported on the water supply and drainage of Saragossa. In 1875 he was again in Madras in connection with the tramway system, and in that year he and his brother collaborated in a treatise on *The Construction of Tramways*. In 1876 he was engaged in experimental work for the treatment of ores, and not long afterwards began his experiments with the use of producer gas for internal-combustion engines.

The first internally-fired gas producer was invented in 1839 by the Austrian engineer Karl Bischof (1812-1881), but this, like others subsequently invented, was used to supply gas to metallurgical furnaces. To enable the gas to be used as an engine fuel, it was necessary to remove the tarry products, and for this purpose Dowson introduced coke and sawdust scrubbers. By 1883 he had evolved a satisfactory design of pressure gas plant, and a model dating from that year is now in the Science Museum, to which it was sent by the Dowson Economic Gas and Power Company, established by the inventor at Basingstoke. Some years later he introduced a suction producer-plant. A description of his "double-acting" producer, in which air was admitted at both top and bottom, was given in a paper on "Gas Producers,"* which he delivered in 1911 at the Institution of Mechanical Engineers. Mr. Dowson was well known as an author of papers, and articles on producer-gas plants, contributing the section on this subject to the *Encyclopædia Britannica* and writing a book on it, of which four editions were published. He became a member of the Institution of Mechanical Engineers in 1881, and served as an auditor in 1901, but he took part comparatively seldom in discussions and contributed only the one paper to the *Proceedings*. The Institution of Civil Engineers, which he had joined as an associate-member in 1871, being transferred to Member in 1884, awarded him a Watt Gold Medal and a Telford Premium for a paper on "The Efficient Working of Gas Plants and Engines," delivered in 1901. He was awarded a silver medal by the Royal Society of Arts, and a premium by the Institution of Electrical Engineers. Latterly, he lived in almost complete retirement, and it is probable that a majority of present-day engineers, while perfectly familiar with the principles and the process associated with his name, were unaware that this pioneer of the gas-engine industry was still alive. Within the last twenty years, the field in which he specialised has become considerably circumscribed by the popularisation of the industrial oil engine, but the developments which he initiated have been of material value and are proving increasingly serviceable in new applications to which modern conditions have given rise.

As we go to press, we have learned with regret of the death of Mr. Summers Hunter, C.B.E., formerly managing director of the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne; and of Mr. Basil H. Joy, who was secretary for many years of the Institution of Automobile Engineers.

DECREASED REGISTRATION OF MOTOR VEHICLES.—Only 10,070 motor vehicles were registered for the first time in Great Britain during November, 1939, compared with 33,833 during the corresponding period in the preceding year. The number of cars taxed on horse-power fell from 23,588 to the low figure of 3,549, the decreases being most marked in the higher horse-power groups, though the number of cars not exceeding 10 h.p. fell from 14,560 to 2,477. On the other hand, tractors increased from 23 to 43, and agricultural engines from 367 to 1,195. Goods vehicles fell from 5,030 to 3,334.

* See ENGINEERING, vol. xci, page 597 (1911).

LETTERS TO THE EDITOR.

APPLICATION OF DIMENSIONAL ANALYSIS TO STRESSES IN RAILWAY TRACK.

TO THE EDITOR OF ENGINEERING.

SIR,—Is it not true that, however useful dimensional analysis may be in the interpretation of experimental results, it cannot reach any but the simplest of conclusions unless reinforced by experiment or by some other form of investigation? If this be so, there is reason to be suspicious when Mr. Michel Daniloff, in his article "Application of Dimensional Analysis to Stresses in Railway Track," on page 660 of your issue of December 15, 1939, arrives at some definite, not to say surprising, conclusions based on dimensional analysis alone. Error, in fact, there is.

The non-dimensional coefficients of equations (3) and (4) do not include two important quantities, the gauge of the track and the longitudinal spacing of the axle loads; the gauge has as much right to inclusion as E_2 and I_2, as each affects the bending of the sleepers, and the spacing of locomotive axles is not sufficient to justify isolation of individual loads. If coefficients covering these two quantities were inserted in equations (3) and (4), Mr. Michel Daniloff's procedure of treating all coefficients as constants would be revealed as leading to nothing more nor less than geometrical similarity; and with geometrical similarity there is no need for elaboration to arrive at the following:—All linear dimensions, of track and rolling stock, and all deflections, $\propto L$; moments of inertia, $\propto L^4$; stresses, as strains are constant, $\propto E$; forces and loads, $\propto E\,I^2$; and $(\text{velocity})^2/g$, $\propto L$. The result, however, is not very illuminating, unless it might be used to design a broad-gauge railway complete with rolling stock, though in this there would be some difficulty in reconciling the axle loads. Dimensional analysis hardly starts until some of the quantities are allowed to vary.

Mr. Daniloff also deduces from equation (3) that "the maximum deflection is proportional to the square of the speed, provided that every factor within the bracket remains unchanged." This would, indeed, be surprising, especially to anyone who has seen track deflections, and it seems to imply that a stationary locomotive produces no deflection. Mr. Daniloff has failed to notice that his condition cannot be fulfilled unless the speed is kept constant, and the conclusion is reduced to the discovery that if everything else is constant so is the deflection.

Yours faithfully,
G. S. GOUGH.

Engineering Laboratory, Cambridge.
December 18, 1939.

[The main conclusions formulated in Mr. Daniloff's article can hardly be seriously vitiated by treating gauge and wheel-spacing as invariable, while the procedure of regarding coefficients as constants is a direct consequence of his avowed intention of indicating conditions under which two tracks of the same gauge will give equally satisfactory performance under loads which may differ appreciably as regards magnitude and speed though not necessarily as regards spacing. Hence the relationship between wheel loading and speed for equal maximum stress is substantially true, as for the condition of rigorous geometrical similarity. It is clear from the opening sentence of the article, and from the later context, that the author's deductions from equation (3) refer to deflection due to moving load. With this interpretation, the coefficient $\frac{\delta_m g}{c_1 v^2}$ remains constant despite variation of v, so long as the non-dimensional groups within the brackets remain constant.—Ed., E.]

THE MANNING OF MERCHANT SHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your article, "The Manning of Merchant Ships," in your issue of December 29, 1939, should be of paramount interest to those connected with marine engineering. This problem has received much consideration by the Institute of Marine Engineers and, during the last three years, it has been the subject of several papers read before the Education Group of that body.

It would appear that there has always been a lack of co-operation between shipowners and the marine engineering firms; the latter have shown no interest in the future careers of their young employees as sea-going engineers, while the owners have only shown interest in engineers when they are ready to proceed to sea. The time is opportune when, from the beginning of their apprenticeship, these young engineers should be partly under the supervision of the shipowners. One has only to compare the systematic training of the engine-room personnel of ships of the Royal Navy with the present lack of system in the recruitment and training of engineering personnel for the Merchant Navy.

Many will agree with your suggestion that the shortage of sea-going engineers is due to the fact that holders of Board of Trade certificates are now well qualified to hold responsible positions ashore. This tendency to obtain posts ashore will continue as long as some shipowners adhere to their present policy. It is gratifying to know, however, that far-sighted owners are building up and maintaining their engineering personnel.

Yours faithfully,
A. C. WEST.

The Polytechnic, Croydon,
January 3, 1940.

FACTORS AFFECTING FLAME VELOCITY.*

By PROFESSOR D. T. A. TOWNEND and DR. M. MACCORMAC.

DR. TOWNEND, the Livesey Professor of Coal, Gas and Fuel Industries at the University of Leeds, is well known for his researches on flame structure, begun in the first place with the late Professor Bone. In conjunction with Mr. Maccormac, who spent a year at Leeds University for the purpose of initiating certain investigations on flame velocity, Professor Townend has given in this paper a short review of recent theories of flame propagation in order to indicate certain chemical issues, raised by these theories, upon which he proposes to carry out work at the university.

The Bunsen burner has a double-cone structure in which the inner cone is an explosion flame, a balance existing between the rate of supply of the explosive mixture, composed of gas and primary air, and the rate of flame-travel through it in the opposite direction. The outer flame is a non-aerated or diffusion flame, its dimensions and intensity depending on the composition and temperature of the gases leaving the inner cone, and the rate of diffusion of its combustible constituents into the surrounding air. The stability of the inner cone depends upon a number of variable factors, including the air-gas ratio, which is controlled by the supply pressure, its specific gravity and the design of the burner. The air-gas ratio influences the rate of flame-travel through the particular primary mixture obtained; and aerodynamical influences associated with the manner of gas flow from the burner orifice also call for consideration. Rate of flame-travel is also held to be a fundamental factor in the general performance of an aerated burner. The flame velocity of the constituents of gas diminishes in the order, hydrogen, ethylene, carbon monoxide, methane, higher hydrocarbons. Because it is not possible to calculate the flame-speed of a gaseous mixture from the flame-speeds of its constituents, recourse is being made to the Aeration Test Burner.† Except in special circumstances, as, for example, when the burners are overloaded or are designed to burn theoretical mixtures, the outer cones of all flames consist mainly of diffusion flames of hydrogen and carbon monoxide admixed with inert gases. There is evidence that certain gases, perhaps those of high unsaturated hydrocarbon content, are prone to abnormal behaviour, particularly in certain appliances; these differences in behaviour may be due to physical or chemical factors. The physical factors might involve differences in the heating up of the burners, the aerodynamical state of the supply, or aeration. The chemical factors influencing the flame-speeds might be affected by a number of causes which it is the purpose of the paper to consider.

The thermal theory of flame propagation of Mallard and Le Chatelier, and the Arrhenius theory of activation energy, have both been abandoned as offering no universal explanation of observed facts. Among facts which led to this conclusion are the disproportionate influence of inhibitors or promoters, such as water vapour, NO_2, and lead tetra-ethyl, the acceleration of slow combustion by inert gases, and the abrupt transition, with some small change in experimental pressure or temperature, from an immeasurably slow reaction to spontaneous ignition and *vice versa*. Many abnormalities have been explained on the basis of the chain theory of chemical processes, whereby it is recognised that the progress of an exothermic reaction depends upon specific encounters between certain reactive chemical species. Any factor affecting the initial concentration of these substances will have an apparently disproportionate influence on the ultimate reaction rate. According to this view, reaction is restricted to the activated centres participating, and general temperature rise does not occur in the system until reaction becomes rapid. Flame propagation is thus to be regarded as conditioned by the building-up in a certain unit volume of the mixture a critical number of reaction centres; the contributing factors will be:—(*a*) rising temperature due to conduction of heat from the flame front; (*b*) actual diffusion of centres from the flame front; (*c*) the formation of centres photochemically by suitable emission from the flame; and (*d*) the presence of any "promoters" actually already present in the explosive mixture. In the present state of knowledge, it is impossible to assess the relative importance of these factors.

In the combustion of complex combustibles, consideration must be given not only to the initial inflammable material, but to that of a number of stable intermediate compounds, to which its partial combustion is known to give rise. With methane, for example, formaldehyde, formic acid and methyl alcohol call for consideration. The time lag in the combustion of hydrocarbons is usually regarded as a period during which an adequate concentration of some intermediate product is built up, at which point the whole reaction becomes autocatalysed. The addition of many intermediate-oxygenated products is known powerfully to promote the combustion as a whole, and aldehydes as a class are very potent in this respect. Flame speeds are determined either by the glass-tube method or by measuring the ignition velocity from a study of the inner cone, the observations involving the cone height, cone angle, or total cone area. Ignition velocity has been found to vary materially with the burner diameter; there are uncertainties in this aspect of the subject, and a lack of agreement between the results of various investigators who have used the cone method. It remains an open question whether the surface-volume ratio of the cones is not an important factor in chemical sensitisation. The effect of inhibitors must also be taken into account; iron carbonyl has been found to have a marked influence in reducing the flame velocity with the slow-travelling flames of CO and air.

Most experimental work, whether in tubes or in burners, has naturally been carried out at atmospheric pressure; it is now apparent, however, that a proper understanding of flame phenomena will only be arrived at when wide pressure ranges have been covered, for under such conditions a much more comprehensive view of the problem can be obtained, and factors which might be disregarded in experiments at any one pressure are then brought to light. As an example, it has recently been discovered that all hydrocarbons and their derivatives with more than three carbon atoms in the molecule give rise not only to normal-flame ranges but also to cool-flame ranges. The normal-flame range centres approximately upon the theoretical mixture for complete combustion, and the cool-flame range usually upon a mixture of 2 : 1 or 1 : 1 between the combustible and the oxygen, or that which is most reactive in slow combustion. Chemically, a cool flame is a slow-travelling, barely-luminous chain reaction and combustion in it is incomplete. The cool-flame ranges occur at lower pressures as the temperature is raised, and eventually the two ranges overlap more and more. At higher pressures in the cool-flame range, a two-stage process is observed, a second but hotter flame being initiated in the cool-flame products; subsequently, the two flames coalesce and the propagating flame then has a double structure. Cool- and normal-flame ranges are usually only well separated with complex molecules. In certain circumstances it may be supposed that a cool-flame process may form some part of the normal-flame structure. Were this to occur critically with change of pressure or mixture composition in any particular case, a corresponding change might be expected in the character of the flame. The inner cones of aerated Bunsen flames of higher hydrocarbons are divided into light and dark segments, and if enough primary air be added, the inner cone rotates at the burner head.

In spite of the modern non-acceptance of the classical views, it is still recognised that temperature is an important factor in flame propagation, and the authors give several quotations from recent papers in illustration of this. Temperature appears to be regarded as assisting the processes that initiate ignition and flame propagation, rather than as being the fundamental cause as was originally supposed by Mallard and Le Chatelier, and by Arrhenius.

* Paper communicated to the Institution of Gas Engineers.

† See ENGINEERING, vol. 148, page 678 (1939).

WORK ON THE ASWAN DAM POWER SCHEME.—It is stated in *The Times* that the Egyptian Cabinet has decided to carry out the Aswan Dam power scheme which was drawn up two years ago and was thought to have been permanently shelved by the outbreak of war. The scheme involves the construction of a large power station, utilising the fall at the dam, the output from which will be employed for the manufacture of fertilisers and other chemicals.

LABOUR NOTES.

THE National Joint Advisory Council, which is composed of representatives of the British Employers' Confederation and the Trades Union Congress, with the Minister of Labour and National Service as chairman, held its third meeting in London last week. An official statement issued at the close was in the following terms:—"General discussion was resumed of the statement made to the Council by the Chancellor of the Exchequer on the problems involved in the financing of the war, and this subject will be further considered at the next meeting of the Council, to be held on January 31. During the discussion, the trades union representatives laid stress on the objections to the control of wages otherwise than by the voluntary negotiating machinery now in existence, and indicated that they were submitting the whole problem to detailed examination. The Council received and considered a statement relating to the construction of the Ministry of Labour cost-of-living index number. The Council considered the advice to be tendered by it to the Government as to the date for the reintroduction of official 'summer time' this year."

A deputation from the staff side of the National Whitley Council of the Civil Service which met the Chancellor of the Exchequer last week asked him to set up a joint committee of the National Council to work out a scheme of compensation to Civil Servants for the increased cost of living. Attention was drawn to the rise in the cost of living since the beginning of the war and to the number of wage and salary increases which had taken place outside the Service. Sir John Simon, in the course of his reply, re-affirmed the Government policy of reviewing Civil Service pay in the light of substantial changes in the level of remuneration outside the Service, but referred to the enormous financial strain on the country as a consequence of the war and to the grave danger of inflation if wages were automatically adjusted to prices. In reply to members of the deputation, who pointed out that it would be difficult to keep Civil Service wages at their present level if prices continued to rise, the Chancellor said that the Government were doing everything in their power to prevent unnecessary rises in prices reflected in the cost of living. He did not consider that the time had yet come to open negotiations on the question of adjusting Civil Service pay.

Wage increases and applications for increases are now so numerous that the whole problem of the remuneration of labour is becoming, from the point of view of the ordinary citizen, extremely confused. The trade unions and their representative bodies—including the General Council—are doing very little to improve matters by encouraging the rank and file to insist on the co-relation of wages and the cost of living. On the economic unsoundness of a policy of making increases of wages march with rises in the cost of living, the Hon. R. H. Brand was fairly convincing in the course of a long article—which he contributed to *The Times* last week. "If," he says, "we go on as we are going, increasing wages as the cost of living rises, and, in addition, gradually add, as we must, a large army of new wage earners, then the inevitable reduction in consumption can be achieved only by prices rising faster than wages—in fact, by the disastrous and unjust process of inflation—a development disastrous particularly to us as a great creditor nation, since it would depreciate the value of all sterling debts due to us."

Mr. Brand proceeds to consider how that may be avoided. In the first place, he says, "it is clear that the trade unions should refrain from demanding increases of wages." "Nothing," he continues, "can justify in present circumstances the 'sliding scale' theory that an increase in cost of living must be followed automatically by a proportionate increase in wages. That is tantamount to saying that the present standard of life of the great mass of the community can, war or no war, always be maintained. The theory may work in peace-time if wealth is increasing or if richer classes exist who can be mulcted to raise the standard of the less rich. But it cannot work now. It would be absurd for all income-tax payers to demand an increase of their salaries and their incomes in proportion as the income-tax increased. It is equally absurd when, for instance, a tax on sugar raises slightly the cost of living for all wage-earners to raise themselves by their boot-straps by demanding and obtaining an equivalent increase in wages."

"But," Mr. Brand goes on to say, "supposing the trade unions and their members recognise the necessities of the case and cease to demand increased wages, this does nothing to solve the problem. It merely prevents it from getting worse. What are the positive remedies? The first and obvious answer is that the increased spending power should be saved and lent to the Government voluntarily if possible, and, if not, compulsorily. Saving is an answer, and a good answer, so far as it goes, but I do not think it is or can be a complete answer. If any article is really in short supply, saving must necessarily be supplemented by rationing; but in my opinion, neither form of saving can 'mop up' the whole increased purchasing power for a simple reason. Were our problem merely to deal with the same number of wage-earners as in peace-time, all drawing higher pay owing to overtime and so on, we might persuade each of them voluntarily to save the increase, or, failing a response, we might without injustice compel each to do so as long as prices were to remain fairly stable. But there will be very large movements of wage-earners between one industry and another, some drawing much higher pay, some the same, and a constantly growing number besides of whom many will be drawing wages for the first time."

Wage increases for employees of Messrs. The Ford Motor Company, Limited, took effect on January 1, and a special "War Time Family Allowance Scheme" was introduced at the same time. These concessions were decided upon by the directors after giving consideration to the increase in the cost of living resulting from the war. Adult employees in receipt of hourly wages have received an increase of a penny an hour, while all salaried employees earning 24*l.* a month or less are given an increase of 15*s.* a month. The family allowance is to be paid to employees whose dependants exceed two, and will be at the rate of 2*s.* a week for every dependant person in excess of that number. Children who have reached school-leaving age are not regarded as dependants.

In reply to the claim of the Transport and General Workers' Union for an addition to earnings on account of the war time conditions of work as well as the increase in the cost of living, the London Passenger Transport Board has agreed to pay the staffs covered by agreements between itself and the union an additional 4*s.* a week (or 1*d.* an hour) for men and smaller increases for women and junior workpeople. The increases will date from "the beginning of the last pay roll week commencing before Christmas." The grades to receive the increase include certain inspectors, all bus and coach, tram, and trolley-bus drivers and conductors, a large number of the engineering staff, and staff engaged on miscellaneous duties.

The General Council of the Wage and Hour Division of the United States Department of Labour warned employers in a memorandum issued on October 19, 1939, that any attempt to continue to pay, to persons employed in excess of 42 hours a week, the same weekly wages as they received before the statutory reduction of normal hours of employment to that figure would constitute a violation of the Fair Labour Standards Act. Time-and-a-half must be paid upon the rate at which the employee is actually employed and paid, and not upon a fictitious rate which the employer adopts solely for book-keeping purposes. Thus, salaried employees must be paid for their hours in excess of 42 a week at time-and-a-half their regular rate, in addition to their former weekly salary. Hourly rates of pay may not be reduced simply in order to yield the same weekly pay after the hours in excess of 42 are calculated at the overtime rate. If employees are given the assurance when their rate of pay is reduced that they will not lose any pay, but will continue to receive their present earnings because certain hours will be computed at overtime rates, the General Council contends that their true rate of pay remains unchanged and that the pretended reduction in rates is contrary to the Act. To determine whether the employer has actually reduced the regular rate of pay, it should be seen whether or not the employee is paid that reduced rate when he does not work the former number of hours, but only the statutory 42-hour week. The above considerations apply also in the case of piece rates. The General Council also stresses the fact that nothing in the Act relieves an employer from any obligation he may have assumed by contract to maintain standards higher than those fixed in the Act.

In reply to a question submitted by the employers whether overtime could be compensated for by means of time off in a succeeding or preceding week, the Wage and Hour Division has indicated that though time-and-a-half must be paid for all hours in excess of the statutory maximum, there is nothing in the Act to prevent any employer from allowing an employee, paid by the hour, to work for fewer hours in the preceding or succeeding week, provided the total wages paid for the two weeks will be just twice the wages due for a normal week. To secure this result the deficiency in hours during the short-time week must be 50 per cent. greater than the excess hours in the week in which overtime is worked. The same considerations apply if the customary pay period covers two weeks. If, however, employment is on a weekly basis and there is an understanding with the employee that he is to receive a stipulated weekly wage whether or not the employer requires him to put in the full number of hours, it would not be possible to cut his pay in a week succeeding or preceding the one in which he worked overtime. Nevertheless, the bonus for overtime worked must be paid.

After ten weeks of war it was highly satisfactory, said Dr. Ley, chief of the German Labour Front, in the course of a recent proclamation to German workers, to find that only a part of the full powers sanctioned by the War Time Economy Order had been utilised and that so far, in the field of wages, a general stabilisation had proved to be sufficient. The eight-hour day had had to be transformed into a ten-hour day, but, according to Field-Marshal Goering, this was to be the limit. In case of very urgent necessity, exemptions might be sanctioned, but only with the permission of the Minister of Labour. Since the introduction of the ten-hour day, the undertakings had been put in a position to distribute hot meals to their staff, for which the Ministry of Food supplied the necessary foodstuffs. The Labour Front was responsible for the establishment of supply offices in all undertakings working 10 hours a day. As increased wage rates for the ninth and tenth hours had been abolished, taxes would be revised so as not to absorb the whole of the workers' extra earnings. If, in exceptional cases, an eleven- or twelve-hour day had to be worked, the usual increases in wages would be paid for such hours. Extra wages for night work, Sunday work and holiday work would, in future, be paid anew. Women were not to be employed on night work.

The American Federation of Labour estimates that in the United States as a whole more than 1,250,000 men and women returned to work between August 1 and October 31. "These seemingly large gains, however, do not," it is pointed out, "nearly bring employment back even to 1937 levels . . . In October, 1939, there were 44,300,000 at work and 9,300,000 unemployed. In October, 1937, we had 45,295,000 at work and 7,179,000 unemployed. Yet industrial production in October, 1939, has been considerably above the October, 1937, volume. Industry is operating at a level 16 per cent. higher, but 995,000 fewer men and women are employed. Also, in these two years we have added 1,126,000 to our working population for whom there are no jobs. This makes a total of 2,121,000 more out of work to-day. To relieve this grave situation of a trend toward greater production with fewer workers, raising wages, shortening hours and keeping prices low are first essentials in building up buying power which alone can create healthy industrial growth."

Following enterprising action taken in many quarters, from public institutions down to individuals, the French Ministry of Munitions has entered into arrangements in many parts of the country with groups which link up similar and allied industries and thus form what might be called "producers' communities." The forms of organisation are very varied and in some cases small workshops have merely united their plant and labour, while in others they have formed a group around a large undertaking and supplement its output with their own. In accordance with instructions given to them, the services of the Directorate of Industrial Manufacture will organise, in the premises of chambers of commerce and chambers of crafts, an exhibition of objects, articles and work, or of photographs of the products which small-scale industry and the handicrafts are best able to turn out.

The heads of districts will be required to indicate the volume of the orders which could be placed in view of contracts given to approved local undertakings, and to furnish information in respect of prices and any other useful information. Thus informed, the delegates of the chambers of commerce, the chambers of crafts and the occupational organisations will carry out a thorough census of the various industrial products of the department, after which they will decide to what extent their members can share in the carrying out of available orders. They will then immediately set up groups of producers for the various branches of industry or for similar and subsidiary industries. As a rule, these groups will be set up under the auspices of public institutions such as the chambers of commerce and chambers of crafts, and each group will concern itself only with its members.

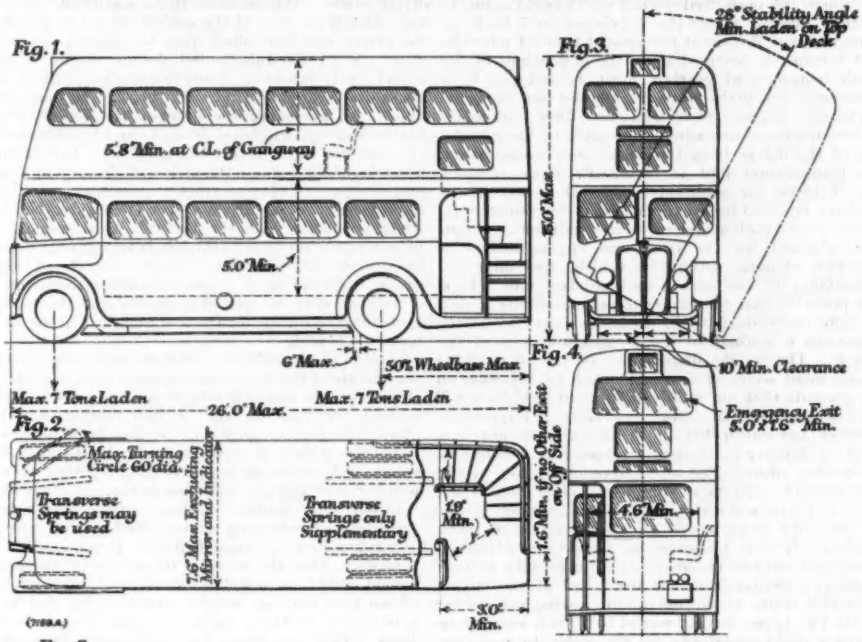
MOTOR TRANSPORT.*

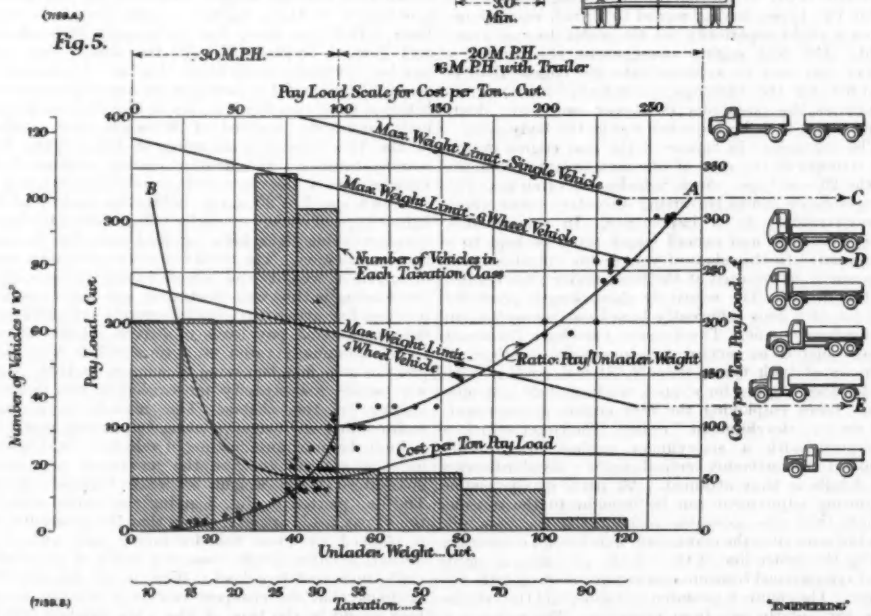
By E. C. OTTAWAY.

AN ordinary goods-carrying vehicle must comply with the requirements relating to this class in the Construction and Use regulations. A public-service vehicle is subject to the same requirements but must, in addition, comply with the Conditions of Fitness, and Equipment and Use regulations. These regulations may, therefore, be regarded as the framework within which the designer may exercise his art. In consequence, an appreciation of the principal limitations which they impose is essential to a proper understanding of the design problems associated with motor transport vehicles in Great Britain. It would be impossible to refer in detail to the whole of the regulations. The more important are summarised in the accompanying table, and many of the minor ones are depicted in Figs. 1 to 4, which show the principal requirements affecting the construction of a double-deck omnibus.

There are two requirements not connected specifically with the construction of the vehicle but which have exerted a large influence on design. The first of these relates to the employment of conductors, and requires that all stage carriages with a seating capacity in excess of twenty and express carriages with a capacity in excess of twenty-six, must carry a conductor. Secondly, the number of persons standing is limited to 25 per cent. of the seating capacity of any one deck and must not in any case exceed five in number on any vehicle. These clauses have a highly restrictive effect, the first in relation to the working of one-man 'buses and the fare systems in general use, the second as a definite limit upon the overload capacity of a fleet of passenger vehicles. This restriction of overload capacity directly serves to increase the cost of travel, and in the author's view is one of the main causes of traffic congestion in large cities. It is probably true to say that Great Britain is the only important country in which the standing capacity of road-transport vehicles is severely limited. It is difficult, in the author's opinion, to see the special circumstances that have dictated this policy, since it inevitably leads to an excess of vehicles to carry peak traffic. Statistics taken in 1935 indicate that the average number of 'buses or coaches passing 28 comparable census points, all busy traffic intersections in Central London, was 4,858 during the day. The average capacity of these vehicles, including the five standing passengers permitted in peak hours, was 59, so that the total passenger capacity was 260,751. Were it possible to use single-deck 'buses of high standing capacity, it is conceivable that the necessary passenger accommodation could be provided by some 3,500 vehicles, a reduction of 28 per cent. in the vehicles passing through the congested area, and representing some 2,716,000*l.* capital.

It has been the purpose of the previous part of this paper to sketch in a background in order that a more vivid appreciation of the engineering problems of vehicle design may be obtained. The vehicles themselves, in their arrangement and design, are a product of this background. It is now proposed to discuss the manner in which they have developed upon certain definite lines in order to serve effectively the requirements of the various classes of traffic, and, at the same time, comply with the statutory and economic limitations.





* Paper prepared for presentation at the American Summer Meeting of the Institution of Mechanical Engineers, September, 1939. Abridged.

Passenger Vehicles.—Passenger traffic may broadly be divided under three headings corresponding to the classification of vehicles for road-service licence purposes. It is now proposed to examine these classifications in greater detail, and to endeavour to show the manner in which the present vehicle types have evolved from them. The operation of a vehicle as a stage carriage implies that it is working a scheduled service at relatively low individual fares, with short fare stages and frequent stops. These conditions may be sub-divided into urban and country working. For urban use, where the density of traffic is considerable and peak loads have to be dealt with, the double-deck 'bus, with a capacity of from 48 to 56 seats, is universal unless low or weight-restricted bridges preclude its use. The development of the double-deck 'bus for dense traffic working has been determined by the restrictions in length and width, and, to an even greater extent, by the statutory limitation of the number of standing passengers to five, reducing the overload capacity of the vehicle to a negligible amount. Traffic congestion and the enforced employment of a conductor on vehicles having more than twenty seats capacity also render the alternative of single-deck 'buses operated at shorter headways impracticable. For country working between small towns and villages, the single-deck 'bus with from 30 to 40 seats is generally preferred, since its capacity is sufficient to deal with the lower density of traffic and some reduction in operational and capital cost is obtained. A very limited use is also made of small vehicles of twenty seats capacity which can be operated by one man, generally for the purpose of developing new routes to be worked by larger vehicles when the traffic has grown to an economic level. The second category, that of the express carriage, defined as a vehicle carrying passengers at separate fares with a minimum fare of 1*s.*, covers all vehicles operating a long-distance scheduled service. This category covers the carriage, with a limited number of stops, of passengers between neighbouring towns. In some instances, notably in London, services of this type provide for business traffic between the city centre and the suburbs and small towns within a radius of 15 miles to 25 miles. These services are complementary to the railway suburban lines, and operate most successfully where the traffic is insufficiently dense to warrant railway extension. For this type of traffic the single-deck vehicle with 30-40 seats capacity is generally used, since there are few instances where double-deck vehicles could be filled

1. WEIGHT.

(*a*) *Passenger Vehicles.*	
Four-wheel double deck. Total	10½ tons (23,520 lb.)
Any two wheels in line transversely not to exceed ...	7 tons (15,680 lb.)
Four-wheel single deck. Total...	9 tons (20,160 lb.)
Any two wheels in line transversely not to exceed ...	6 tons (13,440 lb.)
Six-wheel, single or double deck. Total	12½ tons (28,000 lb.)
Any two wheels in line transversely not to exceed ...	4½ tons (10,640 lb.)
(*b*) *Goods Vehicles.*	
Weight transmitted by any two wheels in line transversely—	
Four-wheel vehicle	8 tons (17,920 lb.)
More than four wheels ...	7½ tons (16,800 lb.)
Trailer	6½ tons (14,560 lb.)
Total weight—	
Four-wheel vehicle	12 tons (26,880 lb.)
Six-wheel vehicle	19 tons (42,560 lb.)
More than six wheels	22 tons (49,280 lb.)
Articulated vehicle	19 tons (42,560 lb.)
Trailer and tractor	22 tons (49,280 lb.)

2. DIMENSIONS.

(*a*) *Passenger Vehicles.*	
Overall length—	
Four-wheel double deck ...	26 ft.
Four-wheel single deck ...	27 ft. 6 in.
More than four wheels ...	30 ft.
Articulated vehicle	Not permitted.
Height—	
Double deck	15 ft.
Single deck	10 ft. 6 in.
(*b*) *Goods Vehicles.*	
Overall length—	
Four-wheel vehicle	27 ft. 6 in.
More than four wheels ...	30 ft.
Articulated vehicle ... ... (Exceptions are made for special vehicles for indivisible loads.)	33 ft.
All vehicles when drawing trailer	26 ft.
Trailers	22 ft., excluding drawbar.
Width—	
Heavy motor cars	7 ft. 6 in.
Motor cars	7 ft. 2 in.

except at such infrequent intervals as would destroy the attractiveness of the service. In cases where the traffic density would warrant the double-deck vehicle, its use has been hindered by prejudice in some quarters, as being unsuitable for sustained high-speed operation. This prejudice is, however, unfounded, and some development in this direction is probable. The third category, the contract carriage, is used for private hire. The vehicles used are generally similar to the coach, with a capacity of 30-34 seats, but may be provided with more luxurious appointments, such as opening roofs, radio, and glass roof panels.

The Double-Deck Omnibus.—The persistence of the rear entrance, in spite of many attempts to popularise alternative arrangements, is almost universal. A few front-entrance double-deck 'buses are used in certain localities, and under special circumstances. It is generally believed, however, that the rear entrance permits quicker loading, enables the conductor to control the vehicle more effectively, and that it gives greater security from boarding and alighting accidents. The limited overall length precludes the use of more than one combined entrance and exit, and under these circumstances the use of doors has been found to increase loading times. It is also the convenient practice of intending passengers to board or alight from the vehicle when travelling slowly in congested traffic, or when stopped by signal lights. Much thought has been given to the possibility of locating the engine beneath the floor, or at the rear, with a view to increasing the space available for passengers. It is clear, however, that the rear entrance, in combination with the low floor height necessary to give adequate headroom and a low centre of gravity, favour the front position for the engine. An alternative arrangement was exemplified in the "Q" type vehicle, with side engine, produced by the Associated Equipment Company in 1933; the arrangement did not find favour and was not perpetuated. There are other reasons for the retention of the orthodox position of the engine in front. The front axle may be placed well forward, with consequent reduced loading, better steering, and road-holding qualities. Furthermore, this arrangement places the objectionable front-wheel arches outside the passenger space, thus obviating the use of inward facing seats, and facilitating a symmetrical interior layout. The double-deck 'bus is limited to 26 ft. overall length and 10¼ tons (23,520 lb.) maximum laden weight if of the two-axle type, or 30 ft. and 12½ tons (28,000 lb.) if of the three-axle type. In consequence of this regulation, considerable interest was taken in the six-wheel type from 1926 to 1933, and many vehicles were built with the object of taking advantage of the increased weight and size permitted. The then London General Omnibus Company built some 1,300 'buses of this type, and the majority are still operating.

A close study of the relative merits of the type under large-scale operating conditions was therefore possible. It became apparent that for urban services, with the variable fare system, it was in many cases difficult for the conductor to deal with seating capacities in excess of fifty-six. Statistics were obtained of the relative operating costs of four- and six-wheel vehicles, which indicated an increase of 11 per cent. in operating cost and some 13 per cent. in respect of capital charges and depreciation, for the six-wheel 'bus. The only advantage which justifiably could be claimed for the type was the superior riding given by the twin-axle construction. This advantage has been subsequently negatived, to some extent, by the introduction of low-pressure tyres on the two-axle vehicle. It was concluded, therefore, on economic grounds, that the six-wheel type could only be justified when traffic conditions and the fare system in use permitted capacities in excess of sixty-five. The relatively low maximum weight imposed by legislation introduces a particularly difficult problem in the case of double-deck vehicles. The distribution of weight on a typical vehicle of this type, of a total weight of 23,520 lb., is: steering, 105 lb.; paint, 229 lb.; indicators, 234 lb.; electrical, 412 lb.; fuels, lubricating oil and water, 420 lb.; windows, fixed and drop, 486 lb.; springs, 750 lb.; chassis frame, 952 lb.; seats, 977 lb.; wheels and tyres, 1,130 lb.; engine, gearbox and dynamo, 2,072 lb.; front and rear axles, 2,838 lb.; body shell, 4,895 lb.; passengers, driver and conductor, 8,120 lb. It will be seen that 8,120 lb. is accounted for by the passengers, driver, and conductor, some 420 lb. for fuel, oil, and water, and 6,821 lb. for body and fittings, leaving a mere 8,159 lb. for the mechanical parts of the vehicle, including wheels, tyres, engine and frame.

Single-Deck Omnibuses and Coaches.—Until recent years, the design of this type of vehicle was not considered independently of the double-deck 'bus. The same type of chassis was used for both, and low overall height was considered æsthetically desirable, even at the cost of headroom and the passengers' view. A high floor, however, reduces the protrusion of wheel arches into the passenger space, and gives a better view. Moreover, low traffic density and long fare stages do not necessitate extremely rapid loading and hence any objection to a double-step entrance is eliminated. The adoption of the high floor has opened the way for consideration of the alternative chassis arrangements, with a view to the more efficient utilisation of the space available and the provision of a greater seating capacity. For the time being, however, the orthodox position of the engine retains its popularity. Two practical alternatives are the rear engine design, which has achieved considerable popularity in America, and the under-floor arrangement, which has also been adopted in a considerable number of vehicles. The location of the engine and gearbox transversely at the rear of the vehicle, with a skew drive to the axle, is practicable where the permitted overall width is 8 ft., but is far more difficult under the restriction to 7 ft. 6 in. ruling in Great Britain at the present time. Under the most favourable circumstances, the dimensions of the clutch housing and gearbox must be reduced to a minimum, and little scope is allowed for epicyclic gearboxes, torque converters, or other automatic devices, rendered increasingly necessary by the remoteness of the driver from the engine and transmission. The transmission unit is necessarily more complex and includes an additional pair of gears. Some difficulty has also been experienced in providing satisfactory engine cooling under adverse conditions. Advantages claimed for the transverse engine include a reduction of noise within the vehicle, and improved accessibility of the engine and gearbox unit. It is also probable that the effects of engine vibration may be more easily dealt with, since the reaction to such vibrations is normal to the longitudinal axis of the vehicle. The weight distribution of the rear engine arrangement seems at first sight open to objection on the grounds that an unduly light front-axle load will have a tendency to cause instability. Experience, however, has shown that, on the contrary, an improvement in stability is effected, together with a reduction in steering effort. The alternative under-floor engine arrangement permits a completely clear floor space for passengers, and a very straightforward transmission layout, with ample scope for special forms of transmission. It also possesses an important advantage in that a front-end radiator may be used with grouped auxiliaries driven from the front end of the engine. A careful study of the maximum seating possibilities of the two types, having regard to British regulations, shows a slight superiority for the under-floor arrangement. The rear engine arrangement necessitates a deeper rear seat to accommodate the engine than is required for the passenger's comfort; moreover, it eliminates the possibility of a rear emergency door, which must then be provided within the body side.

The arguments in favour of the rear engine design are stronger in the case of one-man operated vehicles of the 20-seat type. Such vehicles are often required to operate on routes traversing secondary roads where manœuvrability is of importance. In consequence, their wheelbase and overall length must be kept to a minimum. In this class of vehicle the entrance must necessarily be situated at the front under close control of the driver. The relatively short length precludes the use of a floor sufficiently high to accommodate an under-floor engine. The London Passenger Transport Board placed in service experimentally numbers of vehicles of both types, namely, 34-seat coaches with under-floor engines for express work, and 20-seat one-man 'buses employing the rear engine arrangement, for use on "development" routes. The larger vehicle is equipped with a six-cylinder engine substantially similar to the orthodox vertical engine; standardisation of details is thus attained. All parts of the engine requiring adjustment can be brought to the outside, where they are accessible without the use of a pit. At the same time the crankshaft axis lies approximately along the centre line of the vehicle, providing a simple and symmetrical transmission arrangement on orthodox lines. The engine is mounted on rubber and the vehicles are particularly free from vibration. The radiator is situated at the front. The engine fan, in combination with the ventilating unit, dynamo, and compressor, are driven by a straight cardan shaft from the front end of the crankshaft.

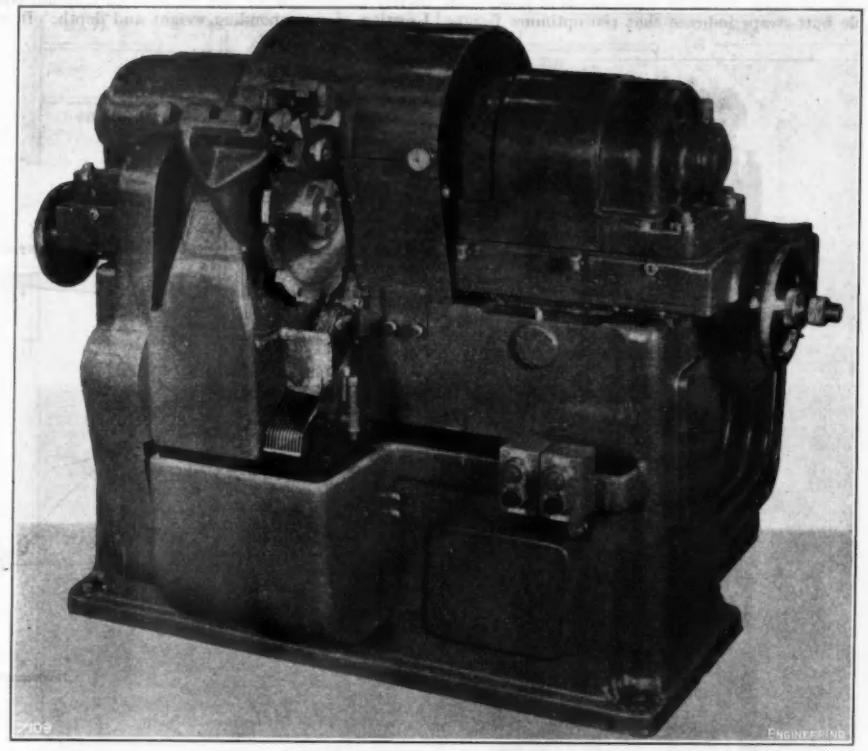
The smaller vehicle of the rear-engine type has the power unit arranged longitudinally at the rear. This arrangement was chosen because the small engine used (3½ in. bore by 5 in. stroke) requires little more space than with the transverse arrangement, and the transmission problem was again simplified. The engine and transmission are arranged as a unit in such a manner that the engine, gearbox, or clutch may be removed separately by withdrawing the internal primary shaft; alternatively, the complete power and transmission unit may be withdrawn from the chassis. Some difficulty was encountered in the early stages of design in providing sufficiently long side shafts to enable the maximum angularity to be kept within reasonable limits. This difficulty was overcome by passing the side shaft through the hub and mounting the universal joint within the dish of the outer wheel; this measure enabled the maximum angularity to be kept within about 6 deg. The alternative positions of the engine outlined above simplify the provision of a full-fronted body, and thus contribute to an improvement in appearance which has generally been accepted. Experience in London, however, has revealed some important disadvantages in comparison with the half-cab arrangement which has hitherto been the accepted practice. The driver's view in bad weather is adversely affected by the increased distance of the major part of the windscreen glass from his eye. In addition, reflections from passing lights and from the interior of the vehicle are more difficult to deal with. Accident statistics have shown the importance of the driver's view. It is desirable that a small child standing immediately in front of the vehicle should be visible to the driver, and that blind spots be reduced to a minimum. With the full-fronted design the waist must be extremely low at the front to give the required view above the near-side windscreen glass. To meet these objections, a compromise between the full front and half-cab design has been devised, and is embodied in the vehicles which have been described; this arrangement has been found extremely satisfactory in service and entails very little sacrifice of passenger space. The improvement of the driver's view is considerable, even when compared with the half-cab arrangement, and by the provision of suitable blinds the driving cab can be completely darkened. During periods of fog, a serious difficulty in our large cities, the nearside window of the cab may be opened outwards and the roadside kerb may be easily seen a few inches in front of the near-side wheel.

Goods Vehicles.—With a view to presenting a composite picture of the factors governing design, the relationships between unladen weight and pay load of some seventy vehicles on the British market has been plotted in Fig. 5, page 47. It has been possible to indicate on this diagram the arbitrary limits of taxation, speed, and maximum laden weight, together with the number of vehicles of each class in use. A study of this diagram will readily disclose certain fundamental considerations affecting the manufacture and operation of goods vehicles in Great Britain. It will be observed, primarily, that the vehicles in use below an unladen weight of 2½ tons (5,600 lb.) greatly outnumber vehicles above this unladen weight, and this has led to the production of these lighter vehicles on a quantity basis. This, in turn, has influenced their design and general appearance. At the same time, the number of vehicles in use above this line of demarcation is not negligible. The fact that the line of demarcation between these two types occurs at the unladen weight limit permitting a speed of 30 m.p.h., has resulted in the two classes overlapping at this point. The manufacturers of the heavier chassis produce light vehicles with a view to carrying upwards of 6 tons pay load at a speed of 30 m.p.h., whilst the makers of the lighter type of chassis normally falling within the lower taxation rating claim high pay load capacities to meet this competition. The tendency of taxation on a basis of unladen weight and speed rating to encourage overloading is thus well illustrated, and the anomalous position has arisen that manufacturers are publishing data permitting pay loads of 5 tons (11,200 lb.) on chassis nominally rated at 3 tons (6,720 lb.). This practice was fast becoming a menace, in that claims were made for capacity far exceeding the designed loading of the chassis. The manufacturers have realised this and are supporting impending legislation to limit the maximum loading of vehicles. It is becoming the practice to give the maximum permissible guaranteed laden weight for each type of chassis. The line plotted in Fig. 5 giving the capital cost per ton of pay load capacity, shows that the minimum cost is reached by those vehicles falling just within the 50-cwt. unladen weight class as a result of their artificially increased pay load. Were it not for this it is probable that the cheapest vehicle in relation to pay load would be the type of which the greatest number are built, namely, the 30 cwt. to 40 cwt. unladen weight class.

The light vans are exclusively of the bonneted type, and disclose their origin by a general similarity of radiator and bonnet to the private car prototype. The light trucks are, in the majority, of the bonneted type, but forward control designs are available in the larger sizes. An analysis of a number of the more representative types shows that, with the forward control, 78 per cent. of the overall length is available as body space, whereas with the bonneted type only 63 per cent. is available. In appearance, the light trucks have developed an individuality like the private car, and follow its rapid changes of fashion. Among the larger and heavier vehicles the appearance is more stable, showing a similarity to the large passenger vehicle prototype. The mechanical design of the lighter vans and trucks follows, in the main, usual lines. Petrol engines are generally fitted, and it may be observed that the number of oil engines in use below the 2½ tons (5,600 lb.) unladen weight classification

PARALLEL-SURFACE GRINDING MACHINE.

MESSRS. HANCHETT MANUFACTURING COMPANY, BIG RAPIDS, MICHIGAN, U.S.A.



is almost negligible. It will be seen from Fig. 5 that for the carriage of loads in excess of 150 cwt. (16,800 lb.) the law demands the use of three axles, and for loads in excess of 260 cwt. (29,120 lb.) a four-axle chassis is required, corresponding approximately to a gross weight of 4 tons (8,960 lb.) per axle. The direct result of this legislation has been uniformity of tyre sizes and interchangeability of axles, the increased load capacity being obtained by a further interchangeable axle. The 36-in. by 8-in. tyre with a load capacity of approximately 2 tons (4,480 lb.) per tyre is almost universal. Much ingenuity has been displayed in attempts to provide the additional axles necessary with the minimum of cost and complication. The suspension of the rear bogie is now invariably by means of four semi-elliptic springs shackled at their adjacent ends to a swinging balance beam; this system affords three points of attachment to the frame and permits of some adjustment of load between the two axles, which is an advantage on single-axle drive bogies. To reduce cost and eliminate the transmission inefficiency of the double-drive rear-axle bogie, it is the practice of several manufacturers to market the six-wheeler with single-axle drive and, in some instances where loading permits, single tyres on the hingmost axle. This arrangement is not entirely satisfactory, in spite of the adjusted axle loadings, since under some conditions adhesion is insufficient. In all cases an alternative design employing double-axle drive is available. With a view to obviating these difficulties, certain manufacturers are employing twin steering front axles and a single rear axle. By this means, the maximum weight is available for adhesion on the driving wheels and tyre scrub is eliminated. Moreover, by the use of twin tyres on the single axle, equal tyre loadings are obtained.

DOUBLE-SPINDLE GRINDING MACHINE FOR PARALLEL SURFACES.

THE accompanying illustration shows the most recent type of double-spindle grinding machine for parallel surfaces constructed by Messrs. Hanchett Manufacturing Company, Big Rapids, Michigan, U.S.A. It will be understood that the two spindles indicated by the term "double" are on the same axis and that each carries a grinding wheel, the part to be ground being passed between the opposing faces of the wheels and thus being finished on both sides simultaneously. The distance between the wheel faces and, therefore, the thickness of the finished part, is determined by stops set by micrometer screws, and the manufacturers state that it is not uncommon to turn out from 60 parts to 70 parts per minute, all of which are within a tolerance of 0·0005 in., both for parallelism and size. For such a rate of production it is necessary to employ mechanical methods for feeding the parts to the wheels. Various mechanisms are employed for this purpose, but perhaps the one most commonly used is that shown in the illustration, viz., a power-driven rotating carrier disc. This plate has hardened Vee-notches on its periphery, into which notches the parts are fed and in which they are automatically clamped, so as to be carried between the wheels, by means of a tension band which is, of course, narrower than the parts themselves. The parts pass between the front halves of the pair of wheels and, on leaving the grinding area, pass out of the region embraced by the clamping band and fall into a delivery chute under the carrier disc.

The grinding wheels of the machine illustrated are 14 in. in diameter and are individually direct-driven by 3-h.p. motors running at 1,200 r.p.m., the current supply being three-phase at 220 volts to 440 volts, and 60 cycles. Fans are mounted on the spindles, and cool air from the base of the machine is thereby circulated through and across the motor windings and discharged through openings at the outer ends of the motor casings. The grinding-wheel discs are also mounted on the motor spindles, which are carried in pre-loaded precision ball bearings, the whole spindle assembly being carefully balanced both statically and dynamically. The grinding-wheel heads are traversed on slides and are so constructed that they can be set either with the faces exactly parallel or, when occasion demands, closer together at the bottom, front or back. Control of the motors is by push buttons and magnetic starters. The type of grinding wheel fitted depends on the class of work being dealt with; plain discs are commonly fitted but cylinder wheels, *i.e.*, wheels of tubular form, are often employed for certain parts, while the segmental type is coming into wider use.

The type of machine illustrated is also made with wheels 12 in. in diameter driven by 2-h.p. motors, as well as in three larger sizes, the largest of which has wheels 30 in. in diameter. It is not proposed to give constructional details here, but only to indicate the general characteristics of the parallel grinding machine which Messrs. Hanchett class as their No. 214 type. Other types vary somewhat; thus, a machine is made with the grinding-wheel spindles driven by Vee-belts from the motors instead of directly, as the belt drive offers considerable latitude in the selection of a suitable speed for the wheel spindles. Similarly, the equipment may be varied, a reciprocating, roller, or chain feed mechanism taking the place of the rotating carrier disc. Typical uses of parallel grinding machines are the grinding of the ends of the eyes of leaf springs, the squaring of the rollers of roller bearings and the truing of roller bearing assemblies.

ELECTRIC WELDING AS AN INTEGRAL PART OF STRUCTURAL DESIGN.*

By PROFESSOR B. P. HAIGH, M.B.E., D.Sc.

(*Concluded from page* 25.)

FATIGUE cracking in welded joints has been investigated experimentally in a variety of ways. In the first place, experimental structures—bridges and ships—have been closely studied in service; and in the second, full-size parts of structures have been tested in large hydraulic "pulsators"—testing machines applying uni-directional pulsating loads up to 50 tons or more under laboratory conditions. In the third place, welded or unwelded samples, cut from structures or from plates specially welded for investigation, have been tested in Haigh electromagnetic machines working with pulsating or reversing loads with ranges up to 7 tons. In the fourth place, small turned samples cut from welded plates have been tested as rotating cantilevers in modifications of the Wöhler testing machine. Tests of the first and second types are of special value, but costly and slow; the information that they have yielded tends to confirm the value of tests on smaller samples. Tests of the fourth type, on small machined pieces cut from welded plates and turned in a lathe that removes the characteristic outer layers of the weld or of the black or corroded plates, yield results that are of considerable scientific value, but are seldom of service as a basis for design. The limiting "safe" ranges of stress are naturally higher than those indicated by samples tested complete with the outer layers, and are often—although not always—grossly misleading. In some instances, the limiting safe range of stress has appeared to be twice as high in Wöhler test pieces as in samples of the full thickness tested in the Haigh machine†; while in others, the strengths have proved nearly equal when the welds were of exceptionally high quality.

In the Haigh machine, an effort was made to obtain sufficient range of load to test representative samples of thick plates and to work as fast as might be compatible with the use of such large sections. The machine works at a frequency of 3,000 cycles per minute, corresponding to over 4 million cycles per working day of 24 hours, and is probably the fastest of all testing machines of comparable capacity. Higher speed, or even the same speed in larger samples, would lead to misleading results on account of hysteretic heating in the metal.‡ The machine, an example of which is illustrated in Fig. 6, on page 50, is designed to reproduce all the outstanding characteristics of the varying loads encountered in different fields of practice. Fig. 7, on page 50, and Table IV, below, illustrate how three typical cycles of loading are classified and specified in other tables that follow. The upper part of the diagram represents alternating, pulsating and reversing cycles of loading A, R and P, with figures (in tons per square inch) corresponding to the results of tests on butt-welds of ordinary structural quality. The cycles may be described by quoting the mean stresses s and the semi-ranges a or, alternatively, by quoting the extreme stresses $s + a$ and $s - a$ as in Table IV.

TABLE IV.

Cycle.	Formula.	Mean-load.	Semi-range.	Range.	Extremes.	
					Pull.	Push.
Alternating A	0 ± 6	0	±6	12	+ 6	− 6
Pulsating R	$+4 \pm 5$	+4	±5	10	+ 9	− 1
Reversing P	$+8 \pm 4$	+8	±4	8	+12	+ 4

In the notation used, + denotes tension and − compression. Whereas cycle A simply alternates between equal extremes of tension and compression, cycle R varies between unequal extremes, the tensile being the greater as the value of s is of + sign. In the pulsating cycle P, the load pulsates in tension without reversing, as the + value of the steady load s is greater than the semi-range a. The lower part of the same diagram, Fig. 7, illustrates how any such cycle of loading may be represented by a single point, A, R or P, in a simple

* The Eighth Andrew Laing Lecture, delivered at Newcastle-on-Tyne before the North-East Coast Institution of Engineers and Shipbuilders, on Friday, November 10, 1939. Abridged.

† *Trans. I.N.A.*, vol. lxxxi, page 84, (1939).

‡ For a description of the Haigh testing machine, see ENGINEERING, vol. 138, page 698 (1934).

diagram that serves the important practical function of presenting the results of successive tests on identical, or, in some instances, different test pieces. The three points A, R and P, for example, have been plotted with ordinates a and absisse s measured along the axes O a and O s from the origin O. The values of $s + a$ and $s - a$ are readily read on the scale of the base-line O s by means of construction lines inclined at 45 deg., as shown for the point P. Alternatively, the values of the same extreme loads may be read by projecting to the inclined axes marked $s + a$ and $s - a$ intersecting at the same origin O. The function of the diagram is to present for comparison or contrast different graphs indicating the limiting conditions under which comparable effects are observed in different circumstances.

The figures in Table IV, above, are representative of the limiting safe stresses for fatigue in butt-welds of "ordinary" quality in mild structural-steel plates. They are based on the results of tests carried out on samples that contained gas-bells and slag-inclusions, and are therefore representative of ordinarily good workmanship with ordinary materials that can be and are surpassed in current practice. They can be used—with appropriate factors of safety—for the design of commercial work subject to severe vibration. When lack of fusion occurs, the figures must be somewhat reduced; but apparently not in any ratio greater than the reduction of area, for the flaws that were present in these samples had already acted as "stress-raisers." The welds were tested with their rough black surfaces intact, as welded; and the figures should not be contrasted with the fictitious values obtained in tests on small machined samples. It appears to be difficult greatly to improve upon these figures in welds made by hand with ordinary electrodes; but improvements up to 50 per cent. can be effected when special care is used to avoid gas-bells and slag-inclusions. A number of series of good hand-made welds have given limiting safe alternating stresses up to 0 ± 8 tons or even 9 tons, instead of 0 ± 6 tons per square inch, as plotted in the diagram and tabulated.

Substantially higher results are found in machine-made welds, probably because larger electrodes are used with heavier currents that are controlled automatically. In a series of 52 samples of butt-welds cut from boilers constructed under current commercial conditions and tested with alternating stresses at 0 ± 11 tons per square inch, an analysis of the direct causes of failure is as follows:—

Unbroken after 12 to 16 million cycles ...	3
Broken, by cracks starting from marks left by the rough grinding of seams	24
Broken, by cracks starting from small gas-bells in the deposited metal	13
Broken, by cracks starting in the plate immediately below thin wash-runs	8
Broken, by slight lack of fusion	4

Butt-welded samples of the silicon-steel plate from Mauretania have been tested at Greenwich by Const.-Lieutenant L. Kirkpatrick and Mr. I-S. Sing, C.N., working in association with my colleague, Mr. T. S. Robertson; and the results are of considerable interest as they illustrate the contrast between hand welding of the highest qualities, and machine welding using large electrodes and exceedingly heavy currents in the Unionmelt process. The limiting safe alternating stresses found in samples with black surfaces on the plates and with the welds ground flat with coarse wheels in the manner that is customary in boiler-making are:—(1) Hand welding with electrodes producing a deposit slightly softer than the plate, breaking through the middle of the deposit, $0 \pm 8\frac{1}{2}$ tons per square inch; (2) hand-welding, with electrodes giving a notably clean deposit, that also broke through the weld in this high-tensile steel, $0 \pm 9\frac{1}{2}$ tons per square inch; (3) Unionmelt samples, breaking in the plate section in contact with the end of the deposit, or through the deposit, 0 ± 13 tons per square inch. The last-mentioned result represents the highest fatigue strength recorded at Greenwich in any welded samples tested with black surfaces.

The attainment of such high limiting safe stresses in butt-welds made by machines with automatic control and heavy currents does not affect the validity of the lower figure of 0 ± 6 as a basis for the design of ordinary structural work; and even this lower figure must be reduced for lapped-joints with fillet welds. The local intensity of stress in a lapped-joint between flat plates is certainly not less than four times the nominal value reckoned from the pull and gross area without regard to the bending action, and it may be more. In two series of lapped joints tested at Greenwich, results as follows were found in samples welded in a shipyard: (1) Joints between flat plate and joggled plate, breaking through the plate section adjacent to the edge of the deposit, 0 ± 2 tons per square inch; (2) joints between plates with edges joggled to angle, breaking in some instances through plate and in others through the fillet, 0 ± 4 tons per square inch. The advantage of the butt-weld over the lapped form, in fatigue strength, is very apparent; and there remains the question for the designer to decide in individual cases, whether the much greater strength of the butt is worth the additional cost of preparation. The above figures represent, probably, the optimum fatigue strength of riveted joints between plates that are joggled and lapped in comparable ways. Tests on single rivets in joints with double butt-straps indicate that the optimum fatigue

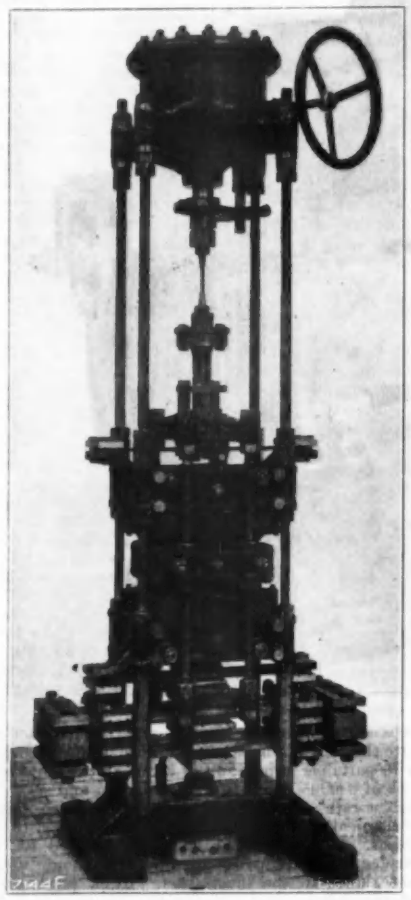


FIG. 6.

strength for well-designed riveted joints of this excellent type cannot exceed $s \pm 3$ tons per square inch; and it is probable that the actual limiting strength is substantially lower.*

It should not be assumed that the full advantages to be gained by welding are immediately available when welded joints are substituted in lieu of riveted. Results of more far-reaching consequence are attained when the plates and rolled sections are rearranged according to the elementary laws of mechanics. It is proposed to describe a few typical changes that we may expect to see adopted. One of the simplest and most remunerative of such changes is the use of symmetrical rolled sections—such as I-bars and deep T-sections—in lieu of channels and Z or other unsymmetrical sections. When shear forces are present as well as bending-moments, unsymmetrical sections warp in a manner that often doubles the nominal stresses due to bending. The first diagram in Fig. 9, above, illustrates the forces acting on different sections in a channel subject to shear force S as well as bending moment. Shear forces S′ act between the web and flanges, and these are balanced, in some degree, by the differences between the tensions T_1 and T_2, for the tensions in the flanges vary in proportion to the bending moment, and, therefore, in proportion to the shear. The line of action of S′ does not coincide with the centre-line of the flange; so that the flanges become subject to additional bending moments. The second diagram illustrates the distribution of the longitudinal stresses under the dual action of the primary and secondary bending moments. The tension in the tension flange is magnified in the part immediately below the web, while the stress in the opposite side of the flange is commonly reversed to act as compression, so that three neutral zones occur in the section, one in the web and one in each of the two flanges. It is believed that this action was first explained by Professor Bach

* *Trans. I.N.A.*, vol. lxxxi, page 84 (1939).

Fig. 7.

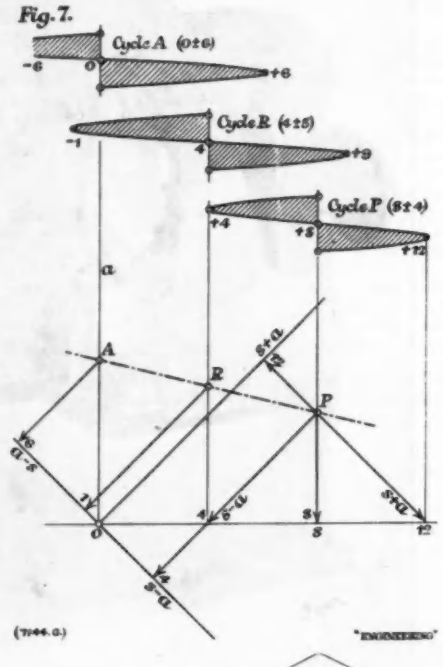
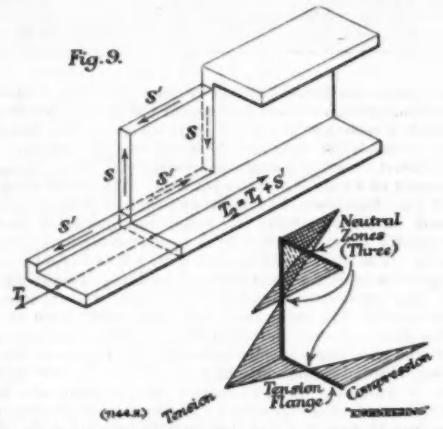


Fig. 9.



nearly fifty years ago, and that it is commonly overlooked.

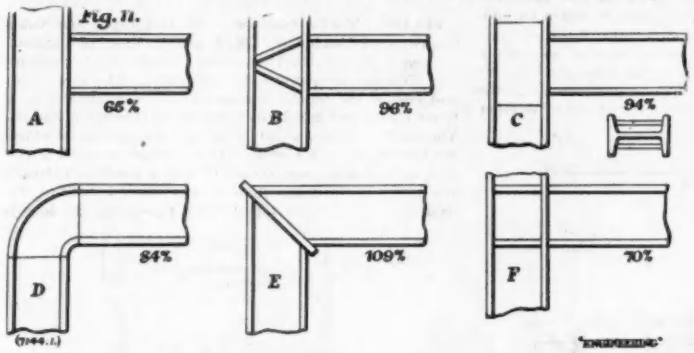
This action was investigated in 1932 at Greenwich by Mr. C. H. Penwill, R.C.N.C.,* who found that a 6-in. by 3½-in. by 16¼-lb. channel, tested in bending on a span of four feet, started to yield with a load approximately 43 per cent. of that required by a symmetrical I-section of corresponding weight and depth. It was found to be lacking not only in strength, but also in stiffness, and it warped and eventually tripped its load. When symmetrical sections are used, with welded joints, calculations based on the lower yield point and on the plastic theory of bending can be relied upon with confidence to indicate the real limiting bending moment, which is commonly twice as great as for the channel of corresponding weight and depth. Even if welded joints were not as strong as riveted, the adoption of welding would be expedient in order that symmetrical sections could be employed. Nevertheless, the fact that joints in structures are commonly located at corners, where the bending moments reach values greater than occur elsewhere, has an important influence on the choice between riveted and welded joints. The design of welded joints for corners merits careful study and experimental investigation. Mr. Penwill's work included such an investigation, and the results are of considerable value.

These joints were tested by tension producing bending moment combined with shear in the corners of L-shaped members welded up from 4 in. by 3 in. by 9½ lb. rolled joists; and Fig. 11, opposite, illustrates some of the many designs tested. Not a single joint failed in the welds; every one failed in a plastic manner by the yielding of the metal in the rolled joists; but the limiting loads varied widely according to how the sections were arranged. The limiting loads quoted in the diagram are those at which the deflection reached a value 50 per cent. greater than the elastic value corresponding to the same load; and it is believed that this criterion affords an effective basis of comparison.

* *Trans. I.N.A.*, vol. lxxv, page 59 (1933).

Type A proved weak, as the flanges of one arm crushed into the inner flange of the other. Type B, with latticed reinforcement, was found to have almost exactly the same limiting strength as a straight sample of the same section—thus reaching 100 per cent. "efficiency"—and type C, with a simpler form of reinforcement, was nearly as strong, and is recommended for general use. In this design, two simple flat plates are welded between the flanges. Type D proved weak; the web yielded at an early stage of loading. Type E, an original Greenwich design that is even now only rarely employed although exceedingly inexpensive and strong, developed the full strength of the rolled section; and type F, which is widely used on the Continent and is there regarded as good practice, proved very weak indeed.

Fig. 11.

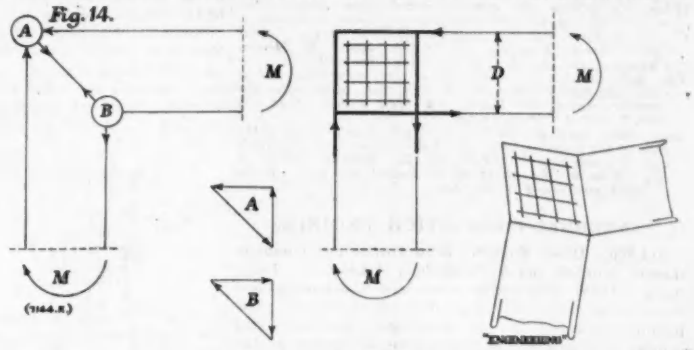


In Fig. 14, on this page, types E and F are contrasted as examples of the application and disregard of the commonsense theorem of the "triangle of forces." In type E, the diagonal is arranged to serve as a tie between the corners, and carries, in the case of a right-angle joint, 41 per cent. more force than the flanges. The joints are held in equilibrium in the simplest possible manner. In type F, equilibrium is impossible without the action of the web in the shaded square, and this part of the web is subjected to a shear force equal to $\frac{M}{D}$, equal to the full tension or compression in the flanges. The webs of ordinary rolled sections are not designed to stand such heavy shears, and the web fails plastically. Type F has less than 70 per cent. of the strength of type E, for rolled sections of equal weight and depth; and type E is the less expensive. The strengths of large riveted and welded structures of types F and E have been recently investigated by the Bureau of Standards, Washington, and the results appear to confirm the above conclusions.

In 1932, Messrs. C. E. Sherwin, A. J. T. Gibbon and H. J. Tabb applied the same principles on a larger scale in the investigation of a practical problem of ship design.* Full-size models were constructed of a standard design of riveted connection between a deck and ship's side-plating, with deck-beams, frames and a flanged knee-bracket, and of a welded design with deck-beams and frames of deep T-section without any knee-bracket, but with the reinforcement described above as type C. The welded design was symmetrical, with frames and beams weighing only 11 lb. per foot, as compared with channels weighing 16½ lb. per foot in the riveted design; thus the frame weights were in the ratio 3 : 2, although of equal depth. The welded design was found to be the stronger by 40 per cent. to 60 per cent., according to the basis of comparison employed. The welded structure had the additional advantage of requiring no knee-bracket. The welded connection was pulled open far beyond the limit of plastic failure, and the weld on the inner part of the right angle eventually sheared away from the rolled section when the shear stress, reckoned on the sheared area, reached a value between 24 tons and 25 tons per square inch.

* *Trans. I.N.A.*, vol. lxxvi, page 35 (1934).

Fig. 14.



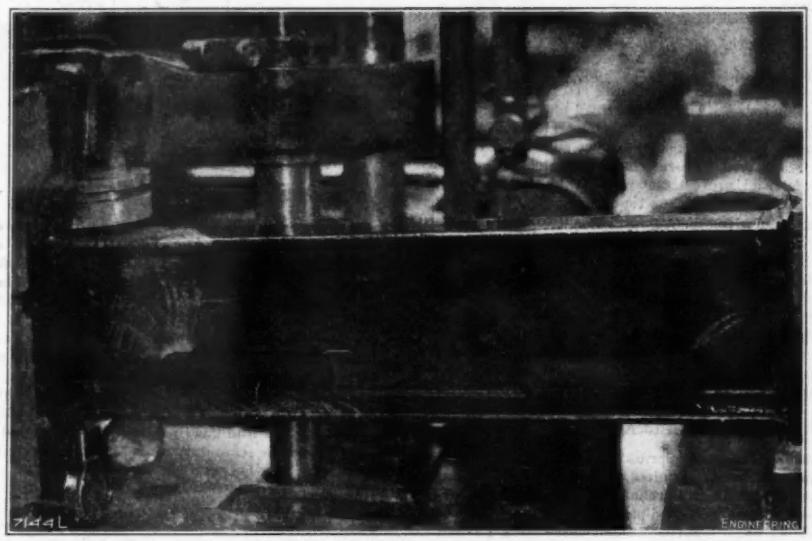


FIG. 16.

Fig. 16, on this page, illustrates an early stage of a bending test carried out in 1936 by Lieut.-Comdrs. Monteiro and da Silva, B.N., on an I-beam, the surface of which had been covered with a thin layer of resin to reveal the location and gradual development of plastic strain in the metal. The view shows only half the length of the span, from mid-span on the left to one of the two supported ends on the right. Lightening holes have been cut in the web, to copy the effects of welded deep T-sections of the "castellated" type; and the view shows how plastic strain develops from the corners of these openings, particularly under the influence of the shear force. The shear force remains constant across the semi-span illustrated, while the bending moment rises from zero on the right to its maximum on the left, where the load is applied.

Thin coats of resin have been used at Greenwich during a number of years and are considered invaluable for revealing the location and gradual development of plastic strain, particularly in structural work. The practice was prompted by the observation that coatings of whitewash, or even of mill-scale, serve the same purpose; and that thick coatings of bituminous enamel in ships reveal the same actions, although less effectively. Long experiments were made with different solutions of resin and other brittle substances; but most of these were disappointing, as traces of the solvent, remaining in the layer of resin, left it in a tough condition that was not brittle enough to flake off the strained parts in a serviceable manner. Success was reached by melting resin on to the surfaces without the use of any solvent, and this process, carried out in different ways (for example, by powdering the resin from a pepper-pot and using a gas-flame as a brush to spread it) is successful on all but the hottest of summer days, when the resin remains still rather too tough to do the best of work. The use of resin in this manner is strongly recommended for structural investigations, and for plastic experimental work in general. It reveals more than the most successful of mathematical investigations. It shows where and how the structure suffers, and indicates the changes that are required to overcome the sources of weakness revealed. It is believed that the use of resin in this manner will largely replace the use of extensometers in experimental work, and of mathematical analysis based on the laws of elasticity, for conclusions drawn from mathematical analyses seldom apply beyond the limits of elasticity and are often misleading. We may reasonably expect that it will contribute to the development of improved forms of welded (or of riveted) structures, and, thereby, to the advancement of structural engineering.

CATALOGUES.

Gravity Conveyors.—Messrs. Herbert Morris, Limited, Loughborough, have sent us a new pamphlet illustrating their method of building up gravity conveyors from standardised parts to suit a variety of industrial requirements.

Industrial Lighting.—Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have sent us the latest edition of their catalogue section relating to electrical fittings and accessories for industrial lighting.

Precision Instruments.—We have received from Messrs. W. Edwards and Company, Allandane Works, Southwell-road, London, S.E.5, a list of the catalogues of precision physical and electrical instruments which are issued by Messrs. Kipp and Zonen.

Ventilating A.R.P. Shelters.—We have received from Messrs. Mellor, Bromley and Company, Limited, Minotaur Works, St. Saviour's-road East, Leicester, a brochure which describes their method of mechanical ventilation, enabling the size of air-raid shelters to be reduced to the minimum.

Fuel Conversion of Petrol Engines.—To facilitate the conversion of engines, fitted to their dumpers, from petrol to paraffin, Messrs. Aveling-Barford, Limited, Grantham, supply a set which can effect the change-over in two to three hours. An illustrated leaflet recently sent to us describes the process.

Ventilating Fans and Air-Filtration Plant.—We have received from Messrs. Keith Blackman, Limited, Mill Mead-road, Ferry-lane, Tottenham, London, N.17, a folder describing anti-gas filtration plant and ventilating fans for air-raid shelters, to comply with Home Office requirements.

Excavators.—Messrs. Newton Chambers and Company, Limited, Artillery House, Artillery-row, London, S.W.1, have sent us a well illustrated brochure describing their excavators, made in two models, for light and heavy duty. These have been improved in design and are now capable, convertible, in one working day, for use as crane, dragline, skimmer or grader.

Earth Testing and Distant Repeater.—Messrs. Evershed and Vignoles, Limited, Acton-lane Works, Chiswick, London, W.4, have sent us a pocket-book on earth testing, which explains in simple language how such tests should be made. Accompanying this was a leaflet describing the Evershed-Midworth distant repeater for controlling distant apparatus.

Electrolytic Plant.—Messrs. The International Electrolytic Plant Company, Limited, Sandycroft, Chester, have sent us a copy of a new edition of their pamphlet on "Oxygen and Hydrogen Production," by means of the Knowles electrolytic cell. The pamphlet contains a considerable amount of technical data, including diagrams showing the current consumption at varying voltages, the relation between current and voltage for different electrolytes, and between voltage and temperature, etc.

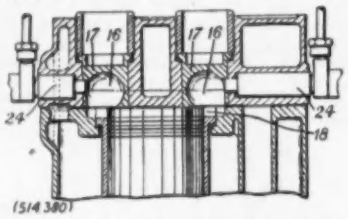
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

INTERNAL-COMBUSTION ENGINES.

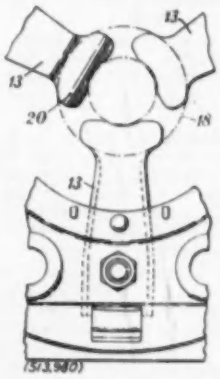
514,380. Diesel Engine. John Fowler and Company (Leeds), Limited, and A. F. Sanders, of Leeds. (3 *Figs.*) April 4, 1938.—The engine is designed to operate at low compression ratios on undoped fuel without knock. The piston is shown at the top dead-centre position. Two compression cavities 16, each have a portion in the cylinder head of spherical shape formed in a detachable block 17 and a portion 18 below the level of the piston head when it is at top dead-centre. These two com-



pression cavities are diametrically opposite, the diameter on which their centres lie being at right angles to that through the centre lines of the inlet and exhaust valves. The oil is successively injected into the cavities by injection nozzles 24, so that when combustion begins in the cavity in which injection first takes place, say, at about 25 deg. before top dead-centre, the increase of pressure increases the final gas influx and the final turbulent swirl in the cavity in which injection next takes place, and the combustion in the latter is, in consequence, more complete, leading to maximum pressures without detonation. Moreover, the new pulse of pressure thus set up now reacts on the first cavity, checking and reversing the flow of partly-burnt gas and assisting in completing the combustion. In this way high mean-effective pressures are obtained without the exhaust becoming visible, and compression ratios as low as about nine to one can be used for small engines and about eight to one for large ones. (*Accepted November* 7, 1939.)

MOTOR ROAD VEHICLES.

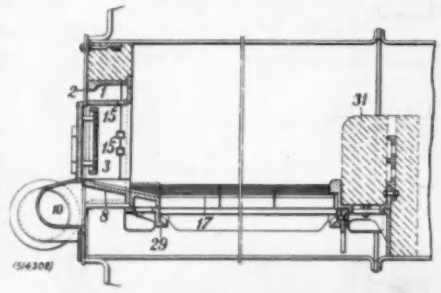
513,980. Friction Clutch. Borg and Beck Company, Limited, of London. (*Borg-Warner Corporation, of Chicago*). (3 *Figs.*) August 24, 1938.—The invention is a method of increasing the area of contact on the withdrawal bearing surface of a friction clutch, the pressure plate being operated by the usual arrangement of clutch springs and



withdrawal levers. The release pressure is transmitted to the withdrawal levers 13 by a collar 18, which engages the inner ends of the levers and has a facing of graphite, or Bakelite. The levers 13 are of sheet metal, and have cylindrical engaging surfaces 20. Such a surface produces line contact which is maintained at all positions of the levers. The ends of the levers 13 are made as wide as possible, so as to make the arc of contact long in relation to its radius. This increases the area over which contact is made during operation of the clutch. (*Accepted October* 26, 1939.)

STEAM ENGINES, BOILERS, ETC.

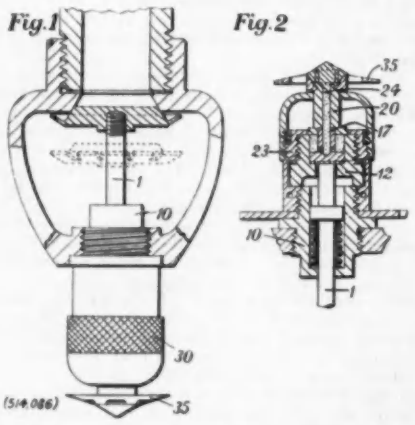
514,308. Boiler Furnace Front. J. and J. Neil (Temple), Limited, of Glasgow, J. M. Neil and J. Welsh, of Glasgow. (5 *Figs.*) May 2, 1938.—The invention is a Lancashire-boiler furnace front which incorporates an air duct. The air duct 1 is located behind the furnace front plate 2 and extends up both sides and over the top of the furnace opening 3. Above the bottom boundary of the furnace opening is a dead plate 8, which extends between the lower ends of the side walls of the opening. The front plate 2 is provided with a hinged door which closes the furnace opening above the dead plate 8, and below the door an air box 10 is fitted which communicates with the air duct through a manually-operated damper.



The inner wall of the air duct has ports 15 through which air is delivered to the front end of the furnace above the grate. The forward edge of the dead plate is higher than the rear edge and is at about the same level as the sides of the grate surface 17. The upper surface of the dead plate 8 is grooved to form channels which become filled with ashes and protect the plate from the heat of the furnace. The opening 3 extends below the door so that the space under the dead plate is open to the air box 10. An inlet valve for the air box is interlocked with the door handle so that the door and the valve cannot be open simultaneously. The outer longitudinal edges of the side sections of the grate are supported by bars carried by the furnace flue. The inner edges of the side sections and the adjacent edges of the centre sections of the grate are carried by parallel bars supported, at the front end, on a cross bearer 29 and at the rear end by the frame of the fire bridge 31. (*Accepted November* 6, 1939.)

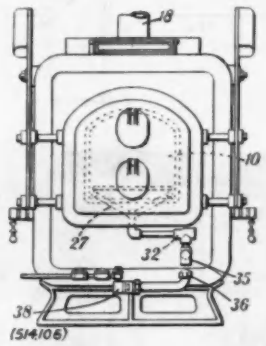
MISCELLANEOUS.

514,086. Automatic Sprinkler Head. Graviner Manufacturing Company, Limited, A. Mathisen, of London, and H. M. Salmond, of Fareham. (3 *Figs.*) April 21, 1938.—The sprinkler is designed particularly for use in aircraft-engine nacelles. A spring-loaded valve stem 1 is guided by a hollow nut 10. The flame-sensitive device consists of a nipple 12 connected to the nut by a fusible sleeve. The nipple receives the end of the stem and has a bore in which the release element for the stem slides. This element consists of upper and lower flanged tubes 17, 20,



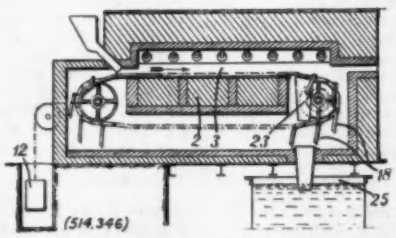
respectively. In the lower tube a pair of fine ignition holes are bored immediately above the flange. The tube projects into the bottom of the upper part, the edge of the flange of which is tapered to engage the rim of a cap 23, which screws on to the nipple 12. The space around the tube 17 forms a chamber which is charged with a small quantity of gunpowder, the charge extending through the tubes of the lower and upper parts to form a continuous ignition channel 24. When the cap 23 is screwed down tightly, the gunpowder charge is confined below the upper flange, the latter being held by the rim of the cap 23, which can be ruptured by the explosion of the charge. When this occurs, the stem 1 is released and operates the valve. A second cap 30 is screwed over the cap 23 to catch the blown out parts. The outer end of the ignition channel 24 is fitted with a priming head made of gunpowder mixed with 25 per cent. celluloid dissolved in acetone, and waterproofed with a thin coating of celluloid dissolved in acetone which also protects it from attack by the fumes present in aero-engine nacelles. A celluloid flame trap 35 concentrates the flame around the priming head. (*Accepted October* 30, 1939.)

514,106. Muffle Furnace. The Gas Light and Coke Company, of London, P. Lloyd, and C. Vyse, of London. (7 *Figs.*) March 23, 1938.—The furnace is of the type in which the atmosphere is controlled. The roof, side, and end of the muffle chamber 10 are surrounded by a space for the hot gases which are led off through a flue 18. The muffle door is a metal frame, on the inner face of which are two layers of firebricks. In the upper portion of the door an outlet passage is controlled by a damper. Through the lower part of the door is a Y-shaped conduit 27, leading to perforated pipes which run along the length



of the muffle chamber close to the floor. The lower limb of the "Y" is connected to a horizontal pipe outside the furnace. On the end of this pipe is a T-piece 32, one limb of which is open to the atmosphere. The lower end of an S-shaped bend 35 is placed over and away from a burner 36. The T-piece 32 operates as a baffle since, should there be a back-pressure surge from the muffle chamber, it will pass out to the atmosphere without reaching the burner. The S-bend 35 operates as a primary flue even during a surge. The burner is attached to a horizontal tube and a mixing chamber 38. The proportion of air and gas in the mixture is varied by the gas valve and the secondary air for combustion enters the flame in the gap between the burner and the S-bend. (*Accepted October* 31, 1939.)

514,346. Furnace Conveyor. Stein and Atkinson, Limited, of London. (*Stein et Roubaix, Soc. Anon., of Paris*). (8 *Figs.*) December 13, 1938.—The invention is a conveyor for an automatic furnace for the heat treatment of light metal pieces. In the furnace the pieces become covered with a film of oxide which causes them to adhere to the conveyor apron and if they are light, they often adhere to it until after they have passed the point where they should fall off, and the invention aims at overcoming this defect. In the interior of the furnace a horizontal brick partition 2 bounds a furnace chamber 3. The partition supports a slide-way for the upper flight of an endless conveyor apron, the return



flight of which passes under the partition through the coolest part of the furnace. This conveyor apron travels round two end drums on hollow water-cooled shafts. The shaft of the exit drum is mounted in fixed bearings, but that of the entry drum is mounted in sliding bearings loaded by counterweights 12. The apron consists of plates 18, each pivoted to two parallel sprocket chains. Each plate is flat with two side ledges and trunnions to engage pivot holes in lugs on the chain links. When assembled, the plates in the upper flight rest upon the slideway and adjoin each other with a slight overlap. At the exit end of the slideway is a chute 23. Each time a plate leaves the slideway it swings by gravity into a vertical position and in its fall strikes the wall of the chute. The shock thus caused ensures that all the pieces supported by the plate fall into the chute. The pieces pass through the bottom of the furnace into the tempering vat 25. (*Accepted November* 6, 1939.)